Water spectrum

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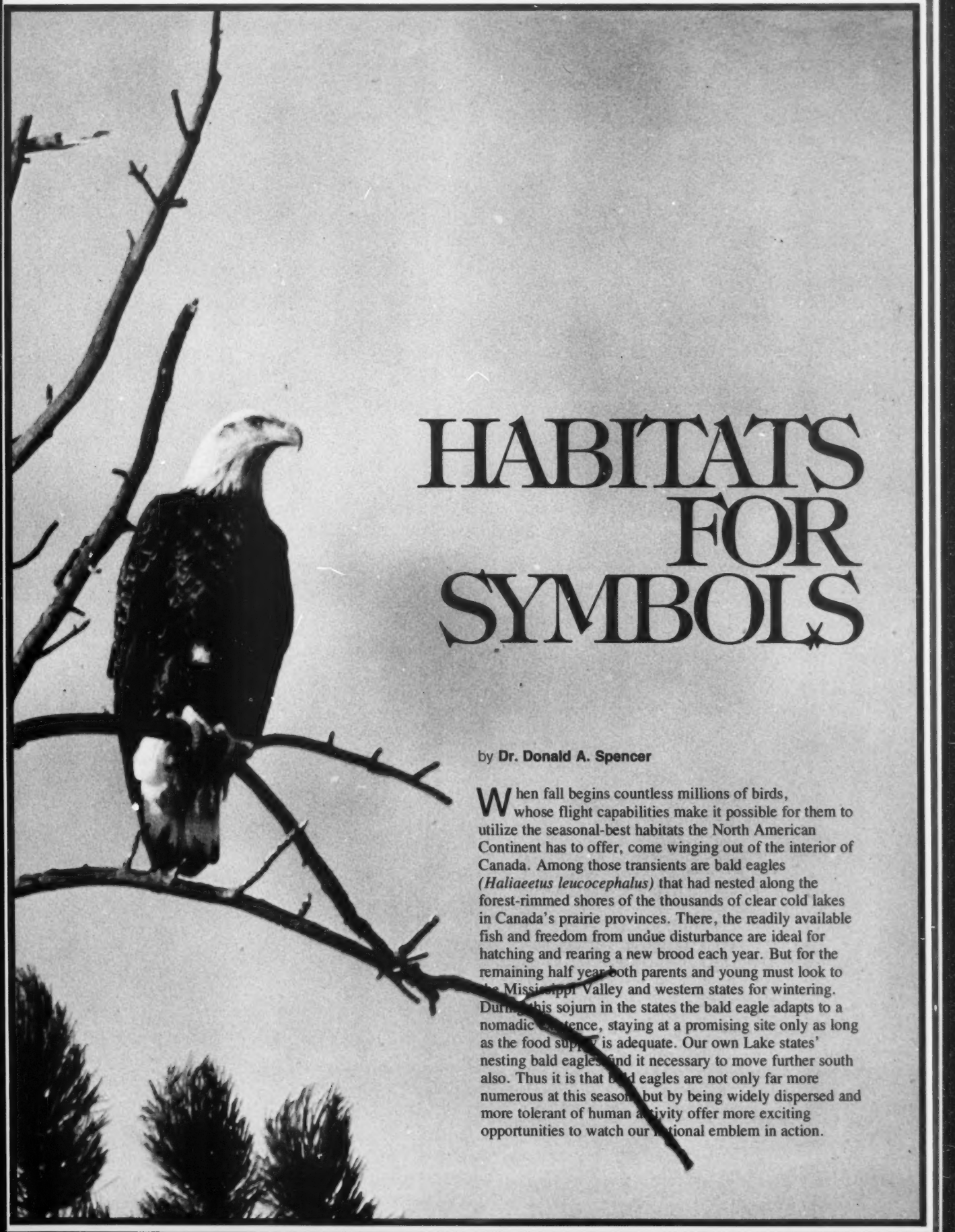
COVER: Winter comes early to Browns River in Jericho, VT.

Photo by George A. Robinson.



HABITATS FOR SYMBOLS

by **Dr. Donald A. Spencer**

When fall begins countless millions of birds, whose flight capabilities make it possible for them to utilize the seasonal-best habitats the North American Continent has to offer, come winging out of the interior of Canada. Among those transients are bald eagles *(Haliaeetus leucocephalus)* that had nested along the forest-rimmed shores of the thousands of clear cold lakes in Canada's prairie provinces. There, the readily available fish and freedom from undue disturbance are ideal for hatching and rearing a new brood each year. But for the remaining half year both parents and young must look to the Mississippi Valley and western states for wintering. During this sojurn in the states the bald eagle adapts to a nomadic existence, staying at a promising site only as long as the food supply is adequate. Our own Lake states' nesting bald eagles find it necessary to move further south also. Thus it is that bald eagles are not only far more numerous at this season but by being widely dispersed and more tolerant of human activity offer more exciting opportunities to watch our national emblem in action.

Aside from the centuries-old drive to seek out the most favorable seasonal habitat on the North American Continent, many species of birds—and bald eagles in particular—make remarkable seasonal changes in behavior. From breeding pairs forcibly demanding exclusive use of shoreline and nesting territory, bald eagles on their wintering rounds may participate in group hunting and will crowd together in a single tree to roost at night. No longer an obligate fisherman, the bald eagle deliberately seeks out locations where a fish kill has occurred or where wounded or sick waterfowl are to be found. The bald eagle effectively uses these animal wastes including carrion from game and domestic animals. Although very sensitive to disturbance during the nesting period, the wintering eagle is not at all adverse to taking advantage of food sources in close proximity to man-made structures and human activity, albeit with guarded caution.

Many people assume that the drastic changes man has brought in the former 'wilderness character' of the lower 48 states seriously diminished the bald eagle's chances of survival on its chosen wintering grounds. There was a time when this may have been true, for in addition to the changing environmental scene, large raptors were commonly regarded as unwanted predators. But those times are past. There are new dimensions in wildlife values. Not only are eagles accorded full protection—with heavy penalties for killing or harassing them—but major efforts have been made to eliminate other factors causing unintentional mortality.

Of equal importance is the fact that in solving some of his own survival problems man inadvertently benefits the bald eagle. Between 1927-1957, the western United States experienced a drought of an intensity and duration that had not occurred in the previous 300 years. The costly lessons of the 'dust bowl' days resulted in the construction of tens of thousands of reasonably reliable water impoundments —from small farm ponds to major reservoirs having a water holding capacity in the millions of acre feet. This improved distribution of surface waters during low flow periods is as great a benefit to wildlife as it is to man. As foci for wintering aggregations of bald eagles the large reservoirs are outstanding.

In the Canadian nesting area winter approaches before bald eagles fledged that year have had time to become very proficient hunters. Fortunately for them vast flights of waterfowl pass the nesting site enroute to their winter grounds in the United States. During this passage hunters cripple some birds which are not recovered. Consequently, the fall migration of bald eagles follows closely the waterfowl flight and the eagles glean dead and crippled birds with little effort—a veritable traveling kitchen. Thus, in early October, waterfowl and bald eagles begin to arrive in the northern tier of states. Since waterfowl pause enroute to feed and rebuild fat reserves lost in migratory

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Dr. Donald A. Spencer, a retired wildlife biologist, spent nearly 40 years with the Fish and Wildlife Service and the Agricultural Research Service. He has authored articles on wildlife subjects for a wide range of scientific and popular publications, including National Geographic Magazine.

flight, so do the eagles. As severe weather and ice eliminates open water, the waterfowl and their bald eagle attendants move still further south or shift to other open water sites. To some degree this association continues throughout the winter and into the spring when both return to the northlands.

Other bald eagles from the Prairie Provinces of Canada solve the problem differently. Being relatively long-lived birds they have had the opportunity to learn where reliable sources of food are to be found and at what date. When such a source is a spawning run of fish, they apparently ignore waterfowl and set a beeline course for a particular river. For example, there is a late fall run of Kokanee Salmon which moves from Flathead Lake in Montana to a shallow stream on the border of Glacier National Park (McDonald Creek). Concurrent with the arrival of the salmon come the bald eagles, experiencing no difficulty in taking fish jam-packed in shallow water or spawned-out and dead on shore and sandbar.

Beginning about mid-October, bald eagle numbers build up along a seven mile length of McDonald Creek and reach counts as high as 377 birds (Nov. 25, 1975).

By the 20th of December they have cleaned up all the fish and have moved on to other wintering sites, leaving this area again deserted.

Each fall since 1965, the staff of Glacier National Park has been censusing the number of eagles using this seven-mile stretch of McDonald Creek by means of weekly canoe float trips. This spectacular fall event draws bird lovers from all over the nation. In 1975 park rangers counted (on weekends only, during October and November) 5,608 visitors at the Apgar bridge, a controlled viewing station.

There is an ironic sidelight to this annual aggregation of bald eagles at McDonald Creek. Fifty years ago it could not have happened. Kokanee are Pacific Ocean salmon whose ancestors became land-locked and adjusted to living their lives in fresh water. They were transferred by man into Flathead Lake about 50 years ago. Since then Kokanee Salmon have also been introduced into suitable large inland reservoirs in California, Oregon, Idaho, Colorado and New Mexico. Bald Eagles have already 'homed-in' on the spawning runs from each and every such successful introduction.

Along the northern coasts natural runs of anadromous fish of several species remain that annually move from the sea into coastal rivers to spawn. The numbers of bald eagles that are attracted to the spawning run on the Chilkat River in southeastern Alaska are almost unbelievable. During the Audubon Christmas Bird Count (Dec. 18, 1976) 1,231 bald eagles were recorded on the 15-mile diameter count circle at Klukwan, Alaska. Only a week earlier 2,107 bald eagles were tallied on the same area.

More modest but still impressive are the 150-200 bald eagles that annually descend on the Skagit River, off Washington's Puget Sound, to feed on the salmon run

The bald eagle in flight is a majestic sight becoming more readily accessible to bird-watchers throughout the United States.

A sizable population of Haliaeetus leucocephalus *has established itself on Alaska's Amchitka Island.*

there. Just a little way to the north another 100-plus bald eagles congregate to feed on salmon spawning in the Nooksack River. One of the newest sanctuaries for the wintering bald eagle is the Skagit.

There are no comparable examples off the New England coast because significant runs of Atlantic Salmon have virtually ceased. However, off Nova Scotia and Cape Breton in the spring, bald eagles can be seen wading out in the shallow water to haul in Gaspereau and other anadromous fish that spawn in the coastal streams.

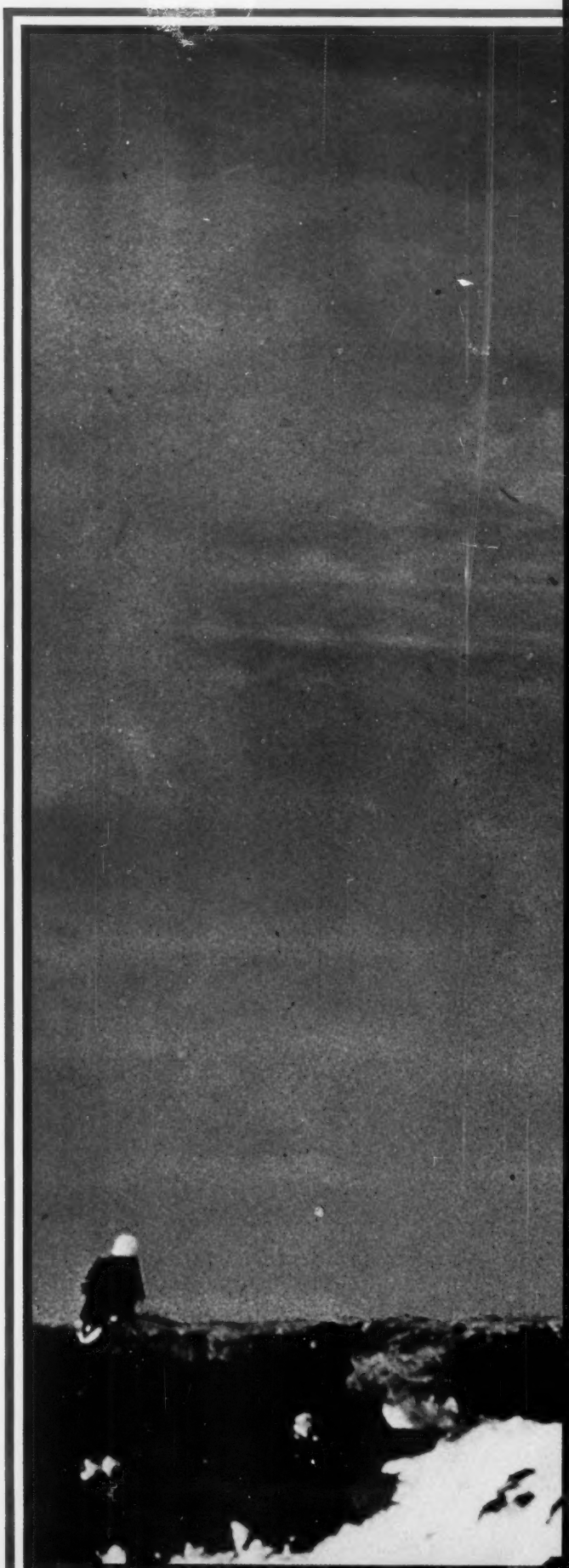
Still other bald eagles from the Prairie Provinces of Canada head for aquatic sites with less dramatic surges of food but promise of winter-long rations. Thus, nearly every lock and dam along the upper Mississippi River quickly receives a contingent of bald eagles commensurate with the supply of stunned and dead fish that are served-up in the tailrace—plus waterfowl using what may be the only open water during the mid-winter freeze-up. The same can be said for nearly every major impoundment dam in the western United States. Last year, when a whitefish kill occurred below the Libby Dam on the Kootenai River in the northwest corner of Montana, fifty bald eagles showed up to 'recycle' the waste. At least 25 bald eagles are annual winter residents along the tailrace of the Toledo Bend Dam—an impoundment on the Sabine River forming the boundary between Louisiana and Texas. If you want to see bald eagles in action try checking with the resource manager at the major reservoir nearest you.

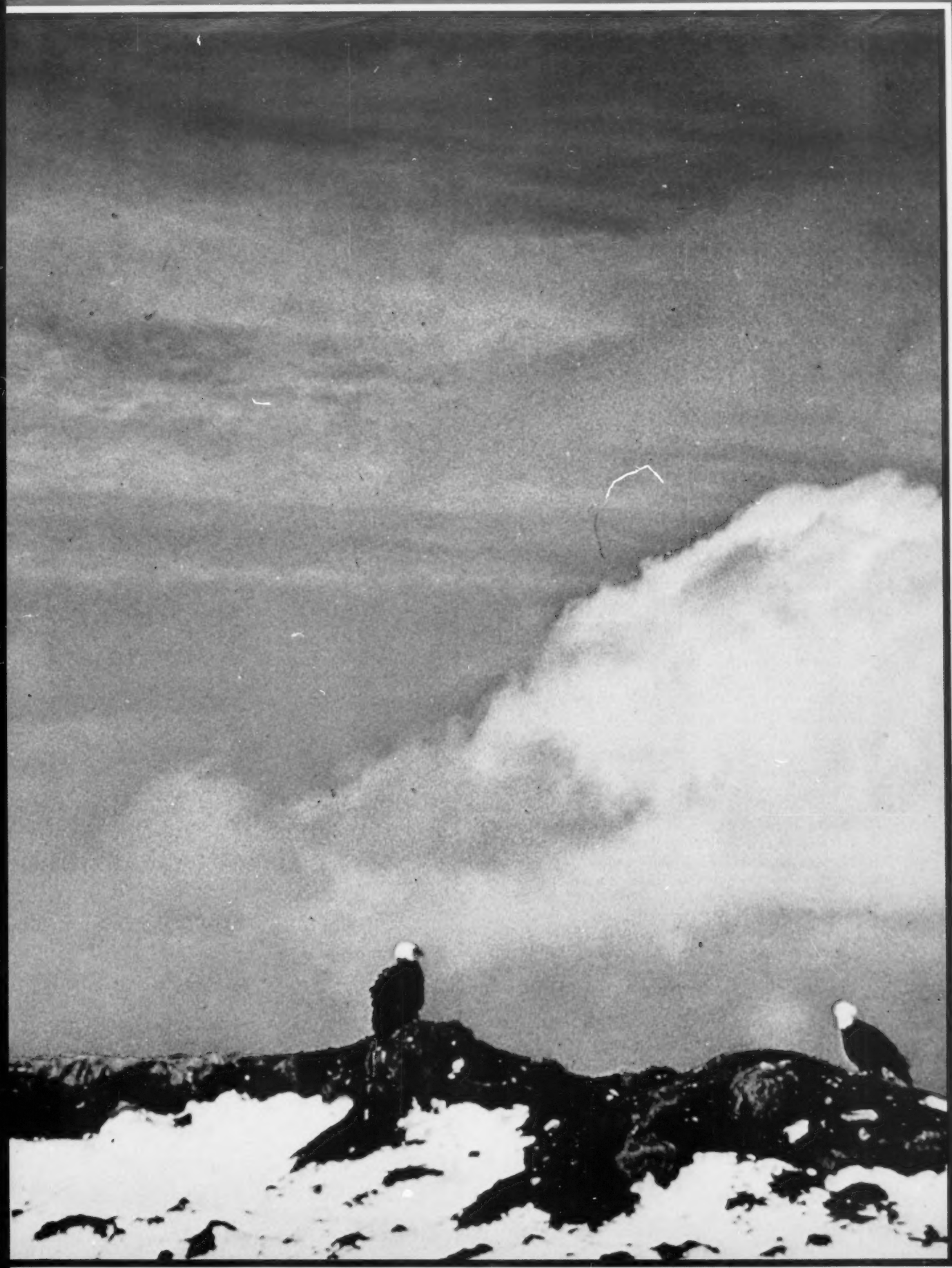
Wintering bald eagles were rarely seen in South Dakota until the series of flood control structures were built on the Missouri River which bisects the State. Now, below Fort Randall dam, the subsequent build-up of migrant bald eagles has sparked the establishment of the first National Wildlife Refuge specifically to protect the bald eagle (the Karl E. Mundt N.W.R., purchased through the efforts of the National Wildlife Federation).

The bald eagle cannot match the osprey[1], the pelican, or even the tern as a fisherman. The bald eagle's prey must be swimming near the surface, where, with no more than getting its feet wet, the bird can snatch the fish from the water in its talons. Not diving from a height like the osprey, but, having spotted a fish near the surface, the eagle takes off on a swift low glide over the water and any dunking therein is a miscalculation on its part. Shallow waters in many locations offer the eagle a fruitful fishing ground. For example, as many as 100 bald eagles head for Reelfoot Lake in Tennessee to spend at least four months at this shallow, cypress-draped lake that was formed by an earthquake about 1812.

The magazine *Southern Living* states, "Just as California's Capistrano Mission has its swallows, so Reelfoot Lake has its bald eagles." Here, too, the State

[1]Benjamin Franklin, in 18th century debate over what species should become the American symbolic bird, called the eagle "a cowardly bird, who steals the osprey's catch." Franklin favored the wild turkey.





Division of Parks has an annual event called Eagle Weekend. The program includes authoritative speakers, motion pictures, and guided tours by boat or car to view the eagles. The information circular urges "Bring your camera" for there are some five blinds for photographers on a first come-first served basis.

At periods of low flow in late fall and winter, rivers such as the Platte in eastern Colorado and southern Nebraska form a network of meandering channels and sandbars. This plus the abundant common carp, provides winter sustenance for a scattering of individual eagles along its length. During complete freeze-up periods, these same eagles turn to roadside kills and mammalian carrion scattered about the adjacent rangelands.

Even the daily fluctuations in water levels downstream from a hydro-electric plant on an impoundment works to the bald eagle's advantage. At low flow intervals fish are isolated in shallow pools and create a functioning "cafeteria" for the eagle.

To avoid giving the impression that bald eagles always select a water habitat for a wintering area, however, it should be understood that there are sizable aggregations of bald eagles whose winter foods consist almost entirely of carrion from both game and domestic animals. In central Utah, in the arid Rush and Cedar Valleys, some 100 bald eagles feed on hunter-killed jackrabbits, various road-killed mammals and birds, and on the carcasses of domestic sheep whose winter flocks number some 40,000. This group of eagles is reported to have attained some skill in capturing jackrabbits for themselves whenever the 'easier to come by' carrion is hard to find. It is on such western rangelands that five or six bald eagles may be observed perched on fence posts along a shrub-covered field. Periodically one of the eagles will take off and fly low over the sagebrush. If a jackrabbit is flushed from cover, its zig-zag escape effort often eludes the eagle—yet it falls victim to a second bird covering the operation. That this small prey should be shared by the group is rather out of character for large raptors.

The least glamorous of the bald eagles' feeding habits during the winter period is that of remaining around cattle feedlots, slaughter houses (in the past), and, in Alaska, the city dump for whatever carrion it can pick up. As many as ten bald eagles have been observed feeding on the carcass of a cow on a Kansas ranch. In Nova Scotia a few bald eagles have been encouraged to spend the winter by deliberately creating a carrion feeding station for them. A most unusual example is that of the dozen or more bald eagles which winter on Massachusetts' ice-locked Quabbin Reservoir. Here deer downed by dogs or dying on the wind-swept ice apparently form the only overwinter food of the eagles.

So with this broad capability to use any and all animal foods, there is hardly a habitat in the United States that the bald eagle cannot make use of as a wintering ground—other factors being acceptable.

The bald eagle commonly hunts and feeds in the early morning and again in late afternoon. On days with strong thermal updrafts it likes nothing better than to use a part of

the day soaring and engaging in aerial chase and acrobatics. But more often it spends the mid-day loafing and preening on a perch adjacent to the feeding site. It may not move from a particular limb of the tree for the entire period. Then, shortly before dusk, the bird will depart to join others at a communal night roost. At some locations, like at Bear River Migratory Bird Refuge in Utah, the marsh is treeless. The eagles have selected a night roost that is 3,300 feet up the side of the Wasatch Mountain Range and 15.5 miles from the marsh. Commuting 10-15 miles between night roost and feeding areas is not at all uncommon in the western states. Even in timbered areas where there would seem to be no dearth of suitable cover for a night roost the eagles may elect a distant site.

Characteristically the roost tree extends above the general canopy and has an open limb structure that permits a bird with a 6-8 foot wing span an unobstructed approach and take off. That the location provides protection from prevailing winter winds is important. While any number of trees at the site may be used for roosting there is much competition for preferred perches and every evening noisy jostling for position occurs. A half hour before full light in the morning eagles will begin flying out of the roost headed for the feeding area. But the roost is seldom completely free of eagles, as some choose to loaf through the day at the site.

Locating such night roosts is an invaluable means of determining the total population of bald eagles using the area. They may be quite dispersed and difficult to locate during the day. For example, midwinter eagle counts are commonly made during an early January aircraft census of waterfowl areas. Such surveys in the Klamath Basin (Ore./Calif.) over a 10-year period averaged only 77 bald eagles. Yet an interagency cooperative effort this past winter located three roosts serving the Klamath Basin which totaled some 498 bald eagles.

The number of bald eagles wintering in the United States is a conservative 10,000. The eastern half of the country shares but few of these raptors, since Quebec and eastern Ontario have no significant nesting population. The limited populations of bald eagles in Canada's Maritime Provinces find no compelling reason for major southern movement. Likewise, the small U.S. population of nesting bald eagles in Maine and along the Chesapeake Bay is essentially non-migratory, as far as biologists now know.

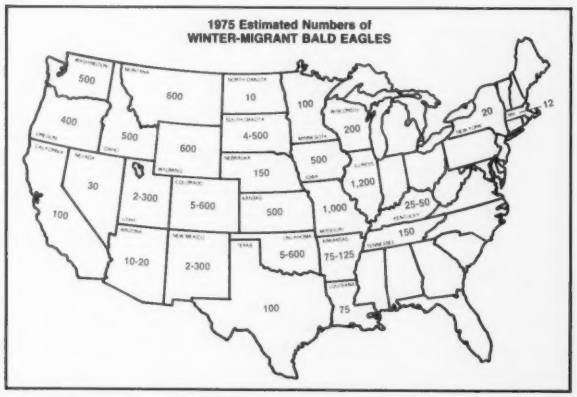
From western Ontario, Manitoba, Saskatchewan and Alberta bald eagles in gratifying numbers move down the Mississippi Valley, hugging the eastern shoulder but spreading west to the Pacific. The leading edge of this annual migration reaches the Gulf of Mexico in Texas, but falls short of infiltrating the Rio Grande Valley in the western part of the State. Bald eagles penetrate to the Bosque del Apache National Wildlife Refuge in southcentral New Mexico, to Mormon Lake below

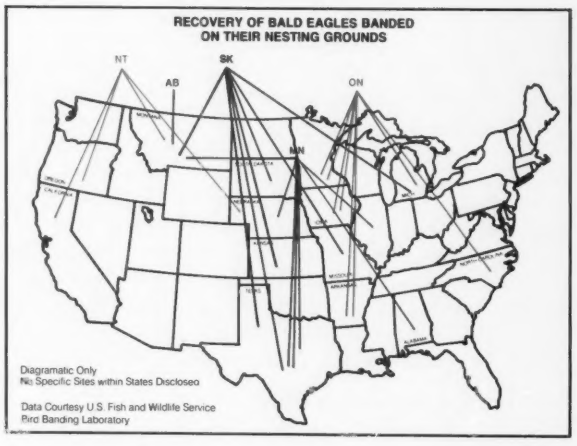
Roost trees, which have been recorded as far as 15 miles from the birds' feeding areas, are an invaluable tool in censusing the migrant populations of the bald eagles. Eagles invariably choose the tallest tree in a roost environment, and will often crowd together on a preferred limb.

Flagstaff, Arizona, and now have been reported as far south in California as Lake Meredith below Los Angeles.

The largest segment of the Continental bald eagle population makes no such annual pilgrimage into the lower 48 States to avoid northern winters. These are the birds along the Pacific Coast from Puget Sound north to Alaska, including the islands of the Aleutian chain. In southeastern Alaska bald eagles reach densities of a nesting pair for every half mile of shoreline. The island-girded coasts of British Columbia and Alaska (plus interior river valleys) provide year-around foods, necessitating only localized movement to take advantage of what the sea provides. Here bald eagle numbers have been estimated at 50,000 birds.

Of the bald eagles that seek out winter sanctuary in the states, including those moving south from nesting areas in the northern tier of states, late February and early March see the beginning of the trek back to the birds' chosen nesting areas. But this 5-6 month experience fortunately comes at a time when bald eagles are accessible to a greater segment of the public, and more tolerant of their presence. The programs now in force that ensure the continuing presence of the wintering bald eagle are succeeding well. ■





Nesting sites for winter-migrant bald eagles are located primarily in the Canadian Prairie Provinces.

INLAND NAVIGATION IN FINLAND

by **M. Heikkila**

M. Heikkila is Chief Engineer, Waterways Division, the National Board of Public Roads and Waterways in Finland.

Following is the fourth in a series of articles written by representatives of PIANC[1] nations. The author portrays Finland as a nation blessed with an extensive natural waterway system, but prohibited from using it freely more than six months of the year by the severe northern European winters.

Any discussion of inland navigation in Finland must begin with a reminder of its location and physical topography—factors which bear uniquely on its use of waterways. The Republic of Finland is situated in northern Europe, and is, after Iceland, the northernmost country in the world. Its land mass covers about 340,000 square kilometers (130,000 square miles), of which 70% is heavy forest and 9% lakes. The population is 4.6 million. Finland's long winters are frigid and ice-bound.

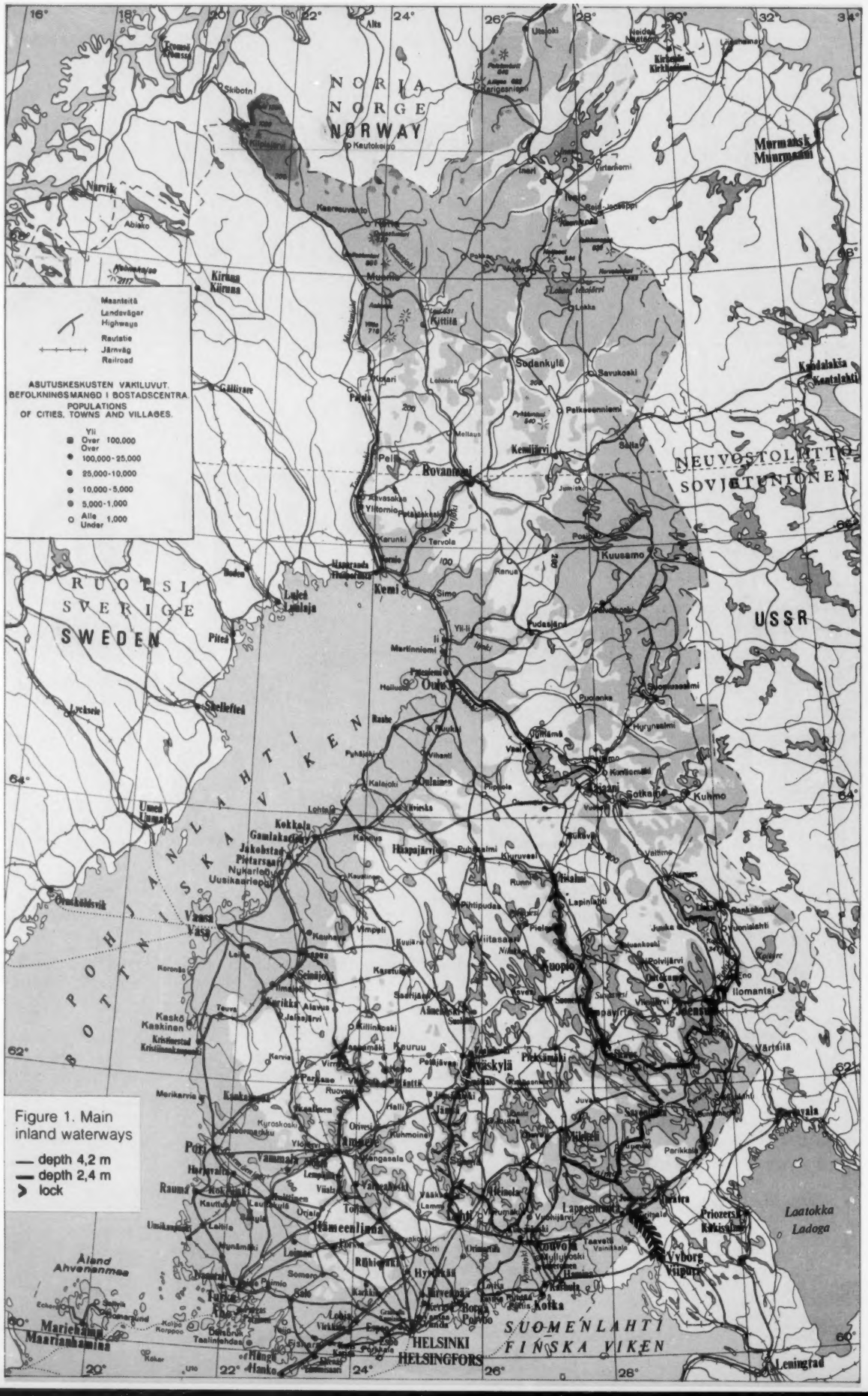
The country has recently changed from an agricultural state into an industrial one, with woodprocessing (sawmill products, pulp, paper and converted products) as the main industry. Other important commodities include metal products, machinery, nutrients, textiles, furniture and design products.

In 1970, 625 million tons were transported within Finland with 592 million being the domestic share. Passengers transported during the same period totaled 1980 million, of whom 1977 were moved by domestic carriers.

Of Finland's foreign trade, 80% is exported westward. Since nearly all of this cargo is seaborne, the country is comparable to an island state as regards its foreign commerce.

Finland's sparse population is clearly concentrated in the south, while the wood processing industry spans the entire nation as far north as the Arctic Circle. This disparity places

[1] Earlier articles pertaining to programs of member-nations of the Permanent International Association of Navigation Congresses appeared in the Winter 1975-6, Spring-Summer 1976, and Winter 1976-7 issues.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BOTTNISKA VIKEN
SUOMENLAHTI
FINSKA VIKEN
Laatokka
Ladoga
Maanteitä
Landsvägar
Highways
Rautatie
Järnväg
Railroad
ASUTUSKESKUSTEN VÄKILUVUT.
BEFOLKNINGSMÄNGD I BOSTADSCENTRA.
POPULATIONS
OF CITIES, TOWNS AND VILLAGES.
Yli
Over 100,000
100,000 - 25,000
25,000 - 10,000
10,000 - 5,000
5,000 - 1,000
Alle
Under 1,000
Figure 1. Main inland waterways
depth 4,2 m
depth 2,4 m
lock

great importance on the viability of the domestic transport system, whose 1970 lengths are as follows:

Public Roads	—	72,400 km	(45,250 miles)
Railways	—	8,800	(5,500)
Sea Channels	—	5,400	(675)
Inland Water Channels	—	6,400	(800)
Commercial Airports	—	16	(10)

The accompanying graph (Figure 2) plots the development, by carrier type, of transportation growth from 1950. The amount and proportion of freight carried by highway transport has shown the most marked increase, rail has decreased and waterborne traffic has remained relatively unchanged in recent years. Rail also received the lion's share of new construction and maintenance investment during the period, with waterways receiving only three percent of funds committed to domestic transport.

> "... The wood processing industry spans the entire nation ..."

Role of the State

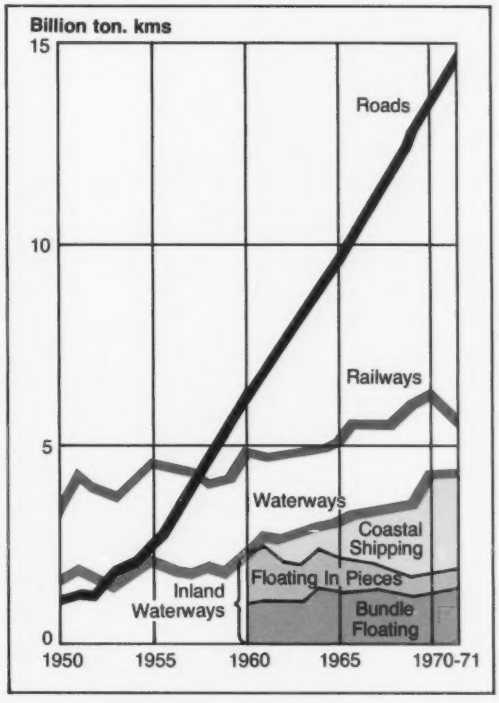
The Finnish transportation field is a mixture of state-steered and free enterprise economy. Specifically, the public authorities (state and municipalities) are in principle responsible for all transport routes, whereas the transportation itself is divided between the state and private businesses. For example, both railway maintenance and rolling stock are state responsibilities, but while inland waterways are under state control, carriers thereon are in the hands of the private sector.

Finland, in proportion to land area, has the most lakes of any country in Europe. There are about 31,600 sq. miles of inland waterways in Finland, or about 9% of the total area within its borders.

The physical features of the country both help and hinder the quality of water transport. On one hand, the ground surface is relatively even, with the lake surfaces on the same levels and forming extensive lake routes. In the lake regions, these routes cover 20-30% of the total area. On the other hand, these lakes are frozen almost half the year. The best forests—the raw materials of the wood-processing industry—are in close proximity to the lake regions. However, the principal lake regions are not naturally connected with the sea, or with each other, and the population centers and industry are principally lakeshore oriented. While channel siltation is practically nil in Finland, the lakes are shallow with bedrock coming near to the surface and imposing limits on the depth and construction of new channels.

To be profitable, water transportation demands great amounts of similar cargoes, be it grains, petroleum products, ores, etc. In Finland, the only cargo that can provide this mass tonnage is raw wood.

Figure 2. Trends in domestic goods traffic



Finland's 55,000 lakes offer a total shoreline of 300,000 kilometers (217,000 miles). Its seacoast is about 4,600 km, with the majority of deepwater anchorages located in the south. The waterway network comprises about 12,000 km of public buoyed channels—5,400 on the sea and 6,400 in inland waters. In addition, there are 9,000 km of unmarked channels. The network includes 25 lockcanals with 32 locks, and 40 excavated open canals (Figure 1).

Bundle Floating

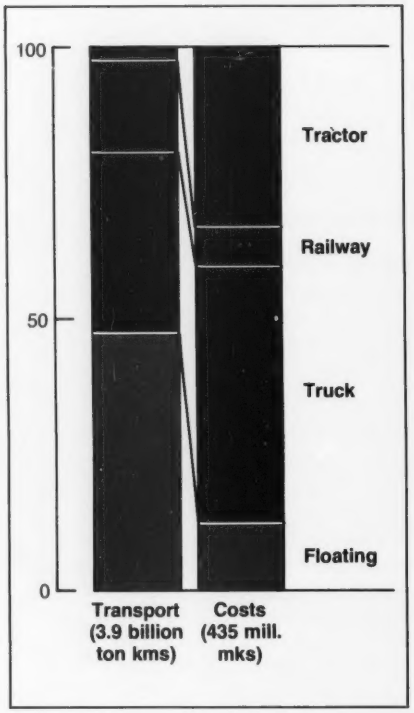
The inland transport of raw wood, the function of greatest importance on Finland's interior waterways, is accomplished by floating the lumber in large bundle rafts such as the one illustrated on Lake Saimaa in the title photo. Nearly half of the wood transported goes by water, through channels that extend well into the inner regions of forest supply areas (Fig. 3).

Timber floating began as loose floating, with logs driven down the rivers singly and moved over the intervening lakes within a boom of logs. The percentage of loose floating in

recent years has been decreasing, primarily due to the uneconomical labor costs involved.

Bundle floated logs are usually harvested in winter and sized in the woods to either sawmill logs or slightly smaller pulp wood. The logs are tied in bundles, and sized again to fit the loading space and the carrying capacity of the truck. Generally, the bundles would be about 15-30 feet in length, with a diameter of 8-10 feet. They are then hauled by truck or tractor to the nearest frozen lake surface to wait for spring (Fig. 4). After the spring breakup of the ice, the bundles are gathered into multi-bundle rafts and moved by tugboat to the waterfront mills. A single such raft can contain as much as

Figure 3. The share of transportation forms of raw wood transport and transportation costs in 1971



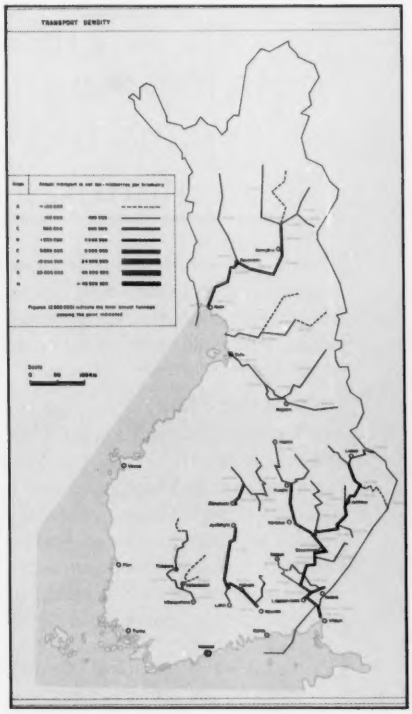


Figure 4.

30,000 tons of lumber, yet draft only about seven feet.

The costs of water transportation are recognized as proportionately lower than other forms of commercial transportation. In Finland raw wood transportation costs in 1971 were calculated as follows:

Tractor	0.400 Fmk/ton/km
Truck	0.160 Fmk/ton/km
Train	0.046 Fmk/ton/km
Bundle Floating	0.016 Fmk/ton/km

(1 Fmk = $.27)

It has been shown that the transportation **performance** of bundle floating in 1970 was **nearly half** of the total raw wood transportation. The profitability rating of bundles comes clearly evident in the fact that floating's share of transportation **costs** was just **13%.**

The most extensive of all inland waterways in Finland, and the most useful from the viewpoint of water traffic, is the Saimaa watercourse in the southeastern part of the country.

Its total area is just short of 70,000 sq. km, two-thirds of which is in Finnish territory.

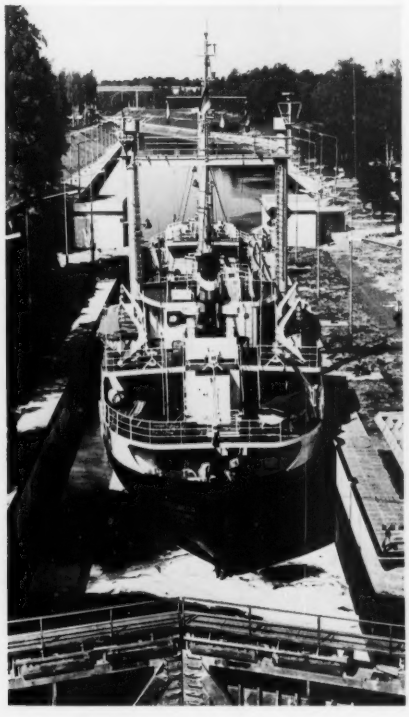
The Saimaa watercourse was connected with the sea as early as 1856 and from that time was integral to the economic life of eastern Finland. The canal, about 60 km long, then drew an investment higher than the annual budget of the country. The early locks were 33.63 × 7.79 × 2.67 meters long. During its busiest years, in the 1920s and 30s, more than 10,000 vessels and about 800,000 tons of cargo transited the canal annually.

The enlargement of the canal to accommodate vessels up to 1,000 tons began as early as 1926 but progressed slowly because of financial difficulties. When the Winter War broke out in 1939, only half of the renovating was completed. The War interrupted use of the canal and in consequence thereof some Finnish territories were conveyed to the Soviet Union. The lower part of the canal thus came to be located on the Soviet side of the border. The canal was heavily damaged during the hostilities. Negotiations with the Soviet Union to get its portion into use were started right after the war, but not before 1960 could these talks be brought to fruition. In 1963 a treaty between the parties was signed in which the Soviets leased the canal-zone situated in their territory to Finland for a period of 50 years. The treaty also stipulated conditions for organization of canal traffic.

> "... It was predicted that annual traffic on the canal would reach a million tons ..."

In principle it was decided that the canal was going to be entirely rebuilt, yet follow the former course. As a design craft for dimensioning the canal, a 2,000-ton ship was selected. The canal now measures 42.9 km—23.3 in Finnish territory and 19.6 on the Soviet side.

From the sea to Lake Saimaa there is a difference in elevation of about 75 meters, which is transited through eight locks, three on the Finnish side and five in the leased zone. Thirteen bridges cross the canal. Concurrently with the construction of the canal, about 400 km of channels were built in Lake Saimaa and some Saimaa District towns were provided with harbors.



The Saimaa Canal, shown here below Malkia Lock, has been Finland's most ambitious inland navigation project to date.

A German freighter transits Malkia Lock, one of eight locks on the Saimaa Canal.

The general design of the canal was undertaken by the National Board of Public Roads and Waterways, which used primarily Finnish consultants for structural design. The Board was also the employer. The work itself was placed on contract, primarily to domestic contractors. Some of the work in the leased-zone was carried out through the Soviet authorities, who invoiced Finland for costs. The canal was finished and opened to traffic in 1968 at a cost over the five-year period of $80 million. The additional channel work in Lake Saimaa itself was $2.7 million.

Passage rights through the Soviet portion are granted all Soviet ships, all Finnish shipping except warships, and merchant vessels of third countries. Finnish traffic regulation is

in force throughout the entire canal, although Soviet pilotage is used in Soviet territorial waters.

Although it was predicted that annual traffic on the canal would reach a million tons, about half that figure is being logged. The main reasons for this shortfall are thought to be changes in industrial structure, changed trade customs, competition with land transport systems, and annual weather closure of the canal for 4-5 months.

Obviously, a traffic channel network requires large initial investments and a means for maintenance each succeeding year. Traffic investment requirements for Finland in 1970 amounted to $32,697 million, of which 9.8% was obligated to waterways. Of traffic maintenance costs ($15,795 million), 2.1% was allocated to waterways. Yet water traffic accounted for 23% of total traffic during the same period. This would seem to clearly demonstrate the profitability of water transportation.

And, it is possible that new and more economical water transport methods (such as barge carrier ships) will enhance canal usage in the future. Still, the Saimaa will never again be of the importance it was prior to World War II as one of the country's commercial transport routes. It and other suitable inland waters are rapidly increasing in significance, however, as avenues for passenger traffic and pleasure boating—phenomenons occasioned by increases in the standard of living and lengthening of leisure time.

Future Traffic Policy

A Finnish Parliamentary traffic committee concluded a three year traffic study in 1974 and its extensive report will provide a foundation for the nation's future traffic policy.

The committee considered these goals crucial:

- ☐ To support and promote the economic growth,
- ☐ To ensure the international competition of the national economy,
- ☐ To support the regional development policy,
- ☐ To promote the traffic safety,
- ☐ To better the quality of living.

Specifically addressing water traffic, the committee stated: "In spite of the fact that the possibilities of water transportation in Finland in many ways are limited, owing to severe winters and the geographical characteristics of inland watercourses, **water transport offers such remarkable advantages concerning economy, energy policy and environment policy, that special efforts ought to be made to promote this form of transportation in traffic policy.**

"The share of floating, in raw wood transportation, is about 40% of the total output. The predominant way of transportation is bundle floating, where the actual travel costs are, to all intents and purposes, the lowest possible. From the point of view of traffic distribution policy the promotion of floating in its most economical field of application, that is to say long transports of raw wood, has to be set up as a goal.

"The increases in prices of liquid fuels and in salaries and wages mean that the rise in price level of traffic forms which consume large quantities of work and energy will have a distinct effect on the distribution of work between traffic forms."

> "... These lakes are frozen almost half the year ..."

In further development of Finland's inland waterways the main ambition will be improvement of the network for bundle floating. No large projects of the magnitude of the Saimaa canal are planned for the next few years. Although possibilities to connect some watercourses and to canalize some rivers are being investigated (the Kemi River in northern Finland and the Kymi in the south), the realization of the projects is still quite vague.

Bundle floating of timber will continue to be of the greatest significance on Finland's water in the forseeable future, with no marked increase in shipborne cargo anticipated. The corollary growth of waterways for use in passenger traffic and leisure boating is on a definite upswing. ■

Finland is surrounded by ice during the winter months, yet faced with the economic imperative of continuing its waterborne import-export trade through a full 12-month navigation season.

During the era of wooden sailing ships, Finland had no winter maritime contact with the rest of the world, and not until the advent of steam propulsion and steel hulls did winter navigation become possible. Her first icebreaker, the MURTAJA, was launched in 1890, and from this humble beginning Finland has emerged as the world leader in icebreaking vessels and technology.

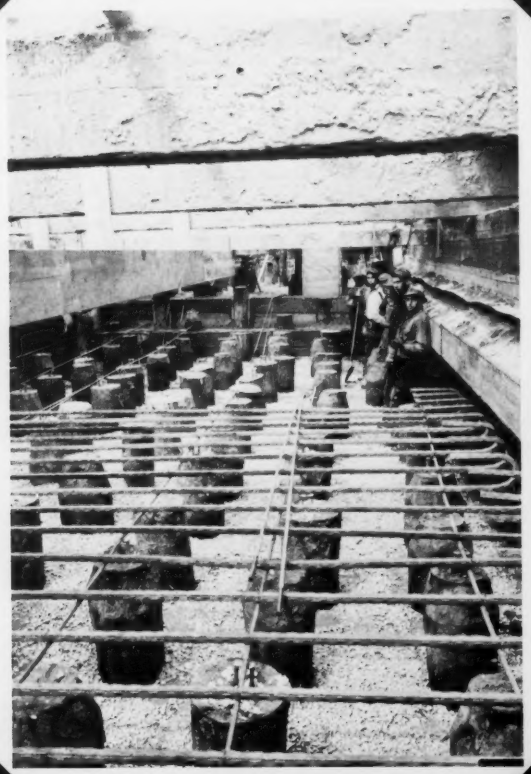
In the last 30 years, Helsinki's Wartsila Shipyard has built 42 diesel-electric icebreakers—more than all other world shipbuilders combined. It backs this production with a research program that includes the world's first model basin specially built for icebreaker design testing. Finnish icebreakers are currently in service in the Soviet Union, Sweden, and West Germany, and on order by Argentina. She is also hopeful of the U.S. and Japanese market. Twelve icebreakers will ply her own waters by the end of the decade.

Finnish equipment ranges from 4,750 shaft horsepower (shp) inland waterway and harbor craft, typified by the ALE (see photo), to the behemoth 22,000 shp class designed for the larger expanses of the Arctic Ocean. The ALE-class vessels are fitted with a water bubbling apparatus which forces air between the hull and the ice to lubricate and reduce friction.

Shipping during the Finnish winter requires not only sufficient numbers of icebreakers, but also merchant vessels strengthened for navigation in ice. Since the Finnish Ice-Fee Classes were established in the 1930's, every vessel arriving in Finland's waters between December 1 and April 30 pays an ice-fee per net registered ton. The fee is highest for ships that are not strengthened and nil for vessels classed 1A Super—approved for navigation in extreme conditions. The ice-fee is an insurance for the owner that his ship will be able to reach a Finnish harbor, and no additional charge is made for icebreaker assistance—unless the vessel must be towed.

Winter traffic is monitored by the Chief of Traffic, Board of Navigation. He radio-directs the movements of the icebreakers, makes harbor closure decisions, and determines if a vessel may enter a port. These decisions are based on ice conditions, meteorological reports, and data on arriving and departing vessels. ■

A grid of reinforcing bars was placed on top of the timber piles just before the concrete was poured in the spring of 1937.



These stumps are the upper ends of 35-foot timber piles that form the foundation of L&D 26.

Water pouring in through cracks in the walls prevented complete dewatering during this 1968 inspection of the filling-and-emptying culvert in the auxiliary lock river wall.

Trials at Alton

by David Chenoweth

Situated below the junction of the Mississippi and Illinois Rivers, the locks at Alton, Illinois, are in almost constant operation. At times, they seem to take on an animated personality, creaking and groaning, leaking and spouting water. Tows float passively in the river, waiting their turn to lock through. There is no outward fanfare or excitement to signal the extraordinary interest centered on this spot.

Locks and Dam 26 are presently surrounded by political and emotional controversy. While the legal battles have only recently begun, the Alton structures have been plagued with difficulties since their earliest days of construction 40 years ago.

This story describes not the current political debate over their future but their trouble-prone past. It tells of the trials the locks and dam have survived and how they were overcome.

Although we could start with 1938 when the locks first opened, or with 1934 when construction commenced the real story begins much earlier.

The rivers of North America were used by Indians for transportation before the rest of the world was aware the continent existed. In the early days of the United States, the rivers provided a way westward. Travel on the water in those days was uncertain, dependent upon the whims of nature for the proper flow—neither too much nor too little. As traffic increased, the fluctuating levels more often caused an interruption and the shippers began demanding flow regulation. The first Federal structures were wing dikes built in the 19th century that narrowed the river, creating a deeper channel.

The Mississippi, filled with water and traffic from its tributaries, quickly became a major water transportation route, carrying goods from all over the country. The river flows in a zig-zag pattern—now east, now west, but ever south to New Orleans and the Gulf. Its basin is the third largest in the world, reaching from within 250 miles of the Atlantic to within 500 miles of the Pacific. It extends from the Gulf of Mexico into Canada and takes in all or parts of 31 States and two Canadian Provinces. Its tributaries spread out like a web: the Ohio River and northeast, the Illinois to the Great Lakes, the Missouri to the west. Along the way, lesser rivers with exotic names of Yazoo and Ouachita and more common names of Arkansas, Red and White add to the flow.

Mr. Chenoweth is a former writer-editor in the Office of the Chief of Engineers in Washington, D.C.

Why a Dam?

Navigation improvements came gradually on the upper Mississippi River. Channels were deepened as traffic grew: 4½ feet in 1878; then 6 feet in 1907; and in 1930, a 9-foot channel, but only from the mouth of the Illinois River to Minneapolis. The early, shallower channels were maintained primarily by dredging and dikes, but the present 9-foot channel could be obtained only by a series of slack-water pools created by a staircase of locks and dams.

The earliest mention of a dam in the Alton area was in a 1905 report on the possibilities of a waterway using the Illinois and Mississippi Rivers to connect the Great Lakes with the Gulf of Mexico. Later studies found that a lock in this area would benefit navigation on both rivers. Eventual construction of the locks and dam at Alton on the Mississippi raised the level of the Illinois and allowed the removal of two outdated and undersized locks dating back to 1890.

Work on L&D 26 began during the Depression years with funds provided under the National Recovery Act. The locks and dam became an authorized part of the Mississippi River waterway 2 years later when the River and Harbor Act of 1935 extended the lower limit to the Missouri River and included the completion of L&D 26 as part of that waterway.

The project was scheduled to be constructed in three stages, each starting with the building of a water-tight cofferdam around the work area. The first stage was the two locks and a short section of the dam on the Illinois side. The second, which started shortly after the first, was the portion of the dam on the Missouri side. The final stage would have been construction of the segment of the dam connecting the previously completed sections.

In February 1936, the cofferdam around the construction area on the Illinois shore was damaged by ice and failed, burying the steel framework under 18 feet of silt and mud. Following this failure, the contractor could not continue, his contract was cancelled, and the debris was later removed by the Federal Government.

The construction schedule had to be reworked. The project would move progressively across the river from the Missouri shore to the intact main lock on the Illinois shore. The auxiliary lock would have to be constructed inside the final cofferdam.

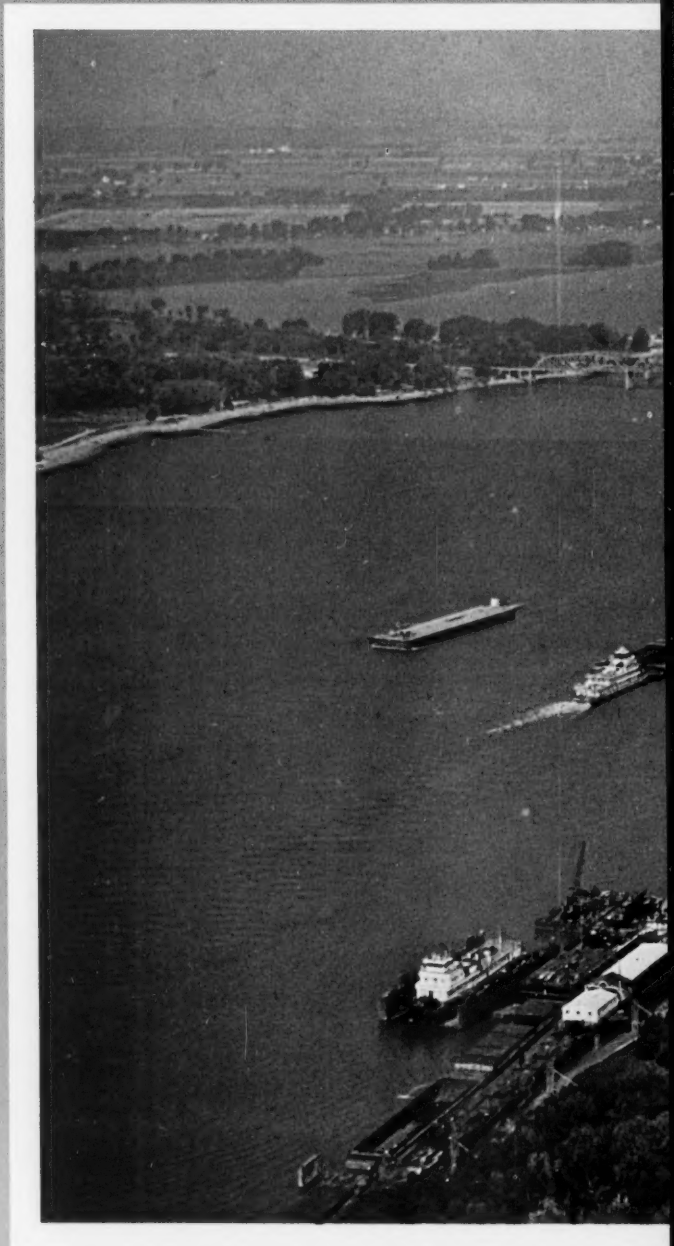
Among the worst of the construction problems to be overcome was the scouring of the river bed which occurred during the building of each cofferdam. Hydraulic dredges in the river upstream of the work areas pumped sand into the flowing water to replace the lost material. In effect, much of the foundation under the locks and dam was placed on dredged fill. Erection of the final cofferdam was particularly difficult. This cofferdam enclosed the area where the first cofferdam failed, and the closure had to block off the main flow of the river—about three-fourths of the total flow. At one point, even with three dredges working, the bottom was eroded to a depth of 25 feet.

Problems continued. After closure, the final cofferdam was over-topped twice by floods, damaging equipment and slowing progress. Then, as the auxiliary lock was nearing completion in the last stage of construction, a large flow of water blew out from underneath the wall between the two locks. The flow was stopped only by driving sheet piling into the foundation and by extensive grouting.

The river had one more surprise to spring. Throughout the construction, water levels remained higher than normal. When removal of the final cofferdam began, the river unexpectedly fell, leaving shallows around the work area. Channels had to be dredged to bring floating equipment close enough to dismantle the cofferdam.

In this 250 mile stretch of the Mississippi River, four navigable rivers come together to form the heavily traveled lower Mississippi River. The locks must handle traffic from all five rivers.

An upbound tow carrying coal approaches L&D 26 at Alton, Illinois. After leaving the lock, the tow will have to immediately swing left to avoid the bulge in the Illinois shoreline above the locks.



An Uncertain Structure

The completed locks and dam are built upon wooden piles driven into the river. The piles are about 35 feet long, while the sand bed in this area of the river is about 80 feet thick over bedrock. The stability of the foundation is dependent upon strong friction resistance between the piles and the sand surrounding them. Because of the scouring and filling during construction, the foundation materials under much of the dam and the small lock are weaker than when originally tested before construction.

Because of this weak foundation, the dam has shifted downstream and settled. Surveys indicate that the dam may have moved as much as 2 inches. All three lock walls have moved varying distances toward the river. The outside wall, built in the area where the first cofferdam failed, has shifted the most—about 10 inches.

As the result of these differential movements, the structure has experienced cracking and joint separation. Water cutoffs between adjoining sections are no longer intact. The resulting leakage has led to erosion, causing voids to develop around the supporting piles. Other holes developed as unconsolidated material settled, resulting in more settling, cracking and leaking, which, in turn, could lead to the development of more voids.

Correction of the structural inadequacies has been a continuing task. In 1938, shortly after the locks opened, extensive water inflows were discovered along the length of the main lock. Voids 5 feet deep had to be filled to stop the flow. Seepage occurred several times through a vertical joint near the Missouri shore and was not permanently stopped until 1947.

More voids were filled in 1954 and 1970. A stabilizing stone berm was constructed in 1970 in an attempt to halt the outward movement of the auxiliary lock river wall. Also in 1970, because of the possibility that the power cables under the locks could be sheared by the movements, an overhead cable frame was erected to insure reliable power for lock operation.

Scour holes have formed in the river bed downstream of the dam. The largest hole is relocated in line with the three roller gates in the middle of the dam. This hole, about 270 feet downstream of the spillway, goes deeper than the tips of the piles supporting the dam. Borings taken in this area show that the river bed, at some time in the past, has been scoured to bedrock; but it is not possible to determine whether the bed eroded before or after the dam's construction. Smaller scour holes are present in spots along the full length of the dam.

Artist's conception of present situation at L&D 26. This accurate rendition was prepared from divers' records and soundings. (Line drawing accompanies this photo.)

Old Locks and Lots of Traffic

To a casual observer, the navigation facilities on the Mississippi River at Alton appear little different from many others to be found throughout the country. The gated spillway is about one-third of a mile long, reaching from the bank on the Missouri side to the locks on the Illinois shore. Both locks are 110 feet wide, the width of most locks in operation today.

The main lock is only 600 feet long, standard for its day but half the length of modern structures. The auxiliary lock is shorter, only 360 feet long.

The locks are neither the largest nor the smallest in operation. They are, however, in a critical stretch of the river, where in less than 250 miles, four major navigable rivers come together. In this stretch, the upper Mississippi, the Illinois, the Missouri and the Ohio merge to form the giant lower Mississippi. All upbound traffic from the lower Mississippi, the Ohio and the Missouri and all downbound traffic from the Illinois and upper Mississippi must move through the locks. There is no alternative water route. The volume of traffic at Alton today is such that the locks are in constant operation, except for emergency shutdown.

Traffic through the locks grew from 1.4 million tons in 1938 to nearly 58 million tons in 1976. During the 10 years between 1966 and 1976, traffic increased over 70 percent, and jams and resultant delays at Alton are now common. In October 1975, one of the busiest months ever, the average delay was 21 hours for tows waiting to lock. During 1975 11 percent of the 5,000 tows that used the main lock waited longer than 20 hours and 1.5 percent waited more than 40 hours. In 1976, the average waiting time for tows using the main lock was over 11 hours.

The location complicates the traffic situation. The Illinois shore bulges into the river just above the locks, obstructing the channel and preventing a straight entry by tows. Before entering, the tows must move out into the river, come back across the current, and then line up for entry into a lock. During high waters, downbound tows entering the locks must overcome a current which cuts across the approach path to the locks. This outdraft makes maneuvering for entry from this direction difficult and increases the possibility for accidents.

A New Structure?

It became apparent in the 1960s that the amount of traffic that could be carried without delay would soon be surpassed and that long delays would result. The dam's physical stability was studied to determine if a new lock could be built through the dam to increase capacity. Analysis showed that the dam was grossly underdesigned by today's standards. Calculations performed to evaluate the stability of the dam had a startling result: the dam had already moved more than thought possible without causing damage to the timber piles.

An actual movement which exceeds design parameters means that either the foundation was weaker than the borings and pile tests indicated or that some factor which could not be included in the analysis, such as vibrations from periodic ice-passing operations, had an effect on the foundation and contributed to the movements. The conclusion was that a weak foundation condition existed and that additional construction in the area of the dam was extremely risky. Based on these results and the limited capacity of the locks, replacement facilities for L&D 26 were proposed in 1968.

The site chosen for the replacement was 2 miles downstream of the present dam. The new structure was to have two locks, each 110 by 1,200 feet—twice the length of the main lock at Alton. The dam was designed with a spillway of nine tainter gates, each 110 feet wide. Two of the gates were to be located between the locks to provide greater ease in simultaneous locking.

Stone berm adjacent to auxiliary lock river wall
Stilling basin
Gate Day Sills (31 total)
Tainter gates (28 total)
Roller gates (3 total)

Congress provided funding for both design and construction, but lawsuits filed on August 6, 1974 stopped progress on the replacement project. The suits charged that an inadequate environmental analysis had been prepared, that the project could cause economic damages to railroads, and that the project was not properly authorized by Congress. Since then, the environmental analysis has been supplemented, and recommendation for a modified project with only a single lock has been submitted to Congress for authorization. Lacking Congressional action, the DOT and the Army Corps of Engineers are currently cooperating in an 18-month Field Test and Investigation Program to try to determine if there is any conceivable way to rehabilitate L&D 26, without recourse to total replacement, which is engineeringly feasible, safe, and cost effective.

Coping—A Two-Sided Problem

In the 3 years since the lawsuit, steps have been taken to ensure the continuing safety of the dam and the smooth processing of the constantly growing traffic.

Although the weakened foundation could not be inspected, detailed studies performed in the late 1960s revealed major structural weaknesses. Of the damages found at that time, the most critical repairs were made in 1970; however, further repairs are now necessary.

Structural problems have been broken into two categories: those needing immediate attention and those requiring more study before repairs are started. Work has begun on both the immediate repairs and the additional studies.

An inspection made as part of the additional studies revealed a hole 300 feet long and as much as 10 feet deep under the downstream end of the wall between the locks. A diver investigating the hole said that the supporting piles were so exposed that it was like walking in a forest.

Filling this hole received priority attention, even though it was not originally scheduled in the first phase of repairs. Both locks were closed for about 10 hours a day during the first part of work and for two 10-hour days near the end of the 3-month job that began in February 1977. The navigation industry was given advance warning; but the closings, of course, jammed up the river traffic.

Other work still to be done includes stabilizing the big scour hole downstream of the dam and repairing holes in gate bay sills and in the stilling basin. An estimated 3 years will be needed for designing and performing these repairs.

When completed, the repair work will not bring the integrity of the dam up to current standards, but it will reduce the chance of failure. This system of repairs is thought adequate

The helper boat "Lil" Charley *pulls the unpowered first cut from the lock and holds it until the powered cut is locked through and the two sections are reconnected.* "Lil" Charley *holds the barges against the De Long Piers that extend the upper guidewall. The large hollow pipes standing behind the barges were jacked into the river bottom to stabilize the piers.*

for the next 10 years, but no one seems willing to predict the situation a decade hence.

The other side of the present problem at Alton is the delay caused by the undersized facilities. Tows in 1938 were much smaller than today, and the main lock and guidewalls were built to carry traffic this size.

Tows approaching or leaving a lock use the guidewalls for alignment, usually by rubbing or bumping against them. The guidewalls at L&D 26 were originally 600 feet long, corresponding to the length of the existing traffic.

The main lock can hold, at the most, either nine standard barges or eight barges and a towboat. Since 1938, towboats have gotten more powerful and barges have been improved in size and shape. With these improvements most tows on the river are now made up of more than nine barges. To get through a 600-foot lock, large tows must be broken into two segments that can each fit in the lock. To begin a lockage, the tow moves into the chamber; the front half is disconnected; and the second half backs away, leaving the first section in the lock. After locking, this section is pulled from the lock, usually by an electric winch located on the lock-wall, and the barges are secured to the guidewall. The second section is then locked through; the two parts of the tow are reconnected; and the tow proceeds on up or down the river.

In October 1976, new procedures were put into effect at L&D 26 that changed the handling of double lockages. The basic objective is to speed processing by reducing the time a lock is dedicated to a specific tow.

Previously, the tows were allowed to remake into the river configuration while blocking the lock chamber. The electric winches pulled the first section far enough along the guidewall for the lock gates to close, but not far enough for the second section to fully clear the chamber while the two sections were being reconnected.

The new procedures require that tows be remade in a position that does not obstruct the lock for subsequent operation. To make this possible, the guidewalls at Alton had to be at least 1,200 feet long, and some means other than the existing winches had to be used to move the first section from the lock.

The upper guidewall was extended in 1976 with three Government-owned DeLong Piers, which are floating platforms sometimes used in salvage work. (Timber piles installed in the 1950s give the lower guidewall an effective length of 1,200 feet.) A helper boat or suiter boat now removes the first section of a double lockage and places it near the end of the guidewall, holding it there until the second section has completed locking and the tow has been remade. During the remaking of the tow, both sections are completely out of the chambers, which frees the lock and allows the next tow in line to begin locking. The helper boats are faster than the winches and can aid in the remaking of the two sections. These boats are not Government-owned but are provided by the navigation industry.

Traffic analysis showed that about every fourth tow that uses the locks at Alton is a configuration that needs little or no rearranging to fit into the chamber and can transit the lock in a single operation. To take advantage of this traffic pattern, tows are now processed in sequences of four in each direction. The process is called "four up—four down," meaning that four upbound tows are locked sequentially, then four downbound, then four upbound, and so on. Whenever possible, a single lockage tow is scheduled last in a sequence. Because a tow of this type does not need the guidewall for reconnecting barges, this schedule allows the first tow in the next sequence to move into the lock area from the opposite direction and start preparing for lockage while the preceding tow is still in the chamber.

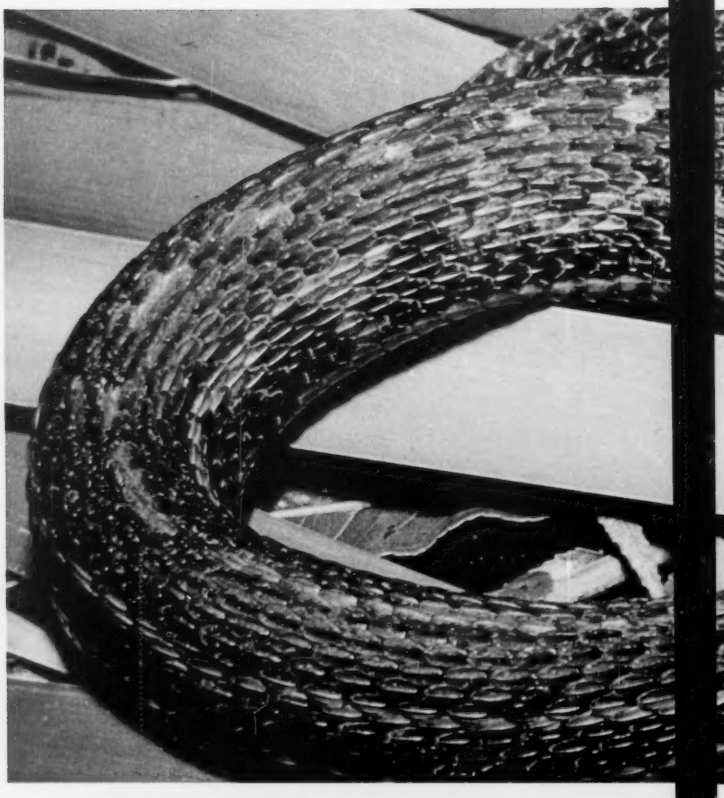
The towboat in this lockage has "knocked out" and moved alongside the barges in the lock, allowing a single operation for the tow. The smaller recreation boats are being transported to Florida, floating in water inside an otherwise empty barge.

The use of longer guidewalls, the helper boats and the scheduling is creating a much smoother traffic flow through the locks. Preliminary results show that the time required for a double lockage may be reduced by as much as 30 minutes a tow.

The future of these locks on the Mississippi River at Alton is clouded. The repairs and operational improvements will not solve the problems. Major repairs will be needed again, but the expensive maintenance will not make the locks and dam structurally sound by present day standards. Operational improvements will not end the delays; they will only allow the locks to partially keep up with increasing traffic. The ultimate answer will have to come from Congress.

Until that time, man will keep struggling with the difficulties. These important old locks, neither the largest nor the smallest, will continue to creak along, spouting water—perhaps in defiance, or maybe out of frustration. ■

Amphibians & Reptiles
The Declining Species



by **C. Kenneth Dodd, Jr.**

The Greeks had a word for it—"herpetology"—the study of crawling things. Amphibians and reptiles are among the oldest groups of backboned animals, the first amphibian having crawled and wriggled its way on to land more than 380 million years ago during the Devonian Period. Reptiles came a bit later, from the Pennsylvanian, about 225 million years ago. Although taxonomically now greatly reduced in numbers and importance, amphibians and reptiles were once the dominant forms of life on earth, and their gradual passing opened up many niches which were later filled by furry and feathered minor offshoots of the great reptiles, the dinosaurs.

Unfortunately, today many species associated with flowing waters are declining, not because they can no longer co-exist with other forms of life found in rivers, bayous, and sloughs, but because they cannot compete with huge tractors and dredges, motorboats and bulldozers, pollution and urbanization.

Millions of years of evolution did not incorporate the genetic plasticity into the genes of most species to allow them to adapt to the rapid modification of their habitats.

Perhaps part of the problem faced by amphibians and reptiles in their relationship with man is simply lack of understanding. The mere idea of a snake evokes in many people the idea of evil, reinforced in modern Western culture by a biblical story in which a snake plays a leading role in the downfall of mankind. In other societies, this has not been the case. In ancient Greece, the python became associated with soothsayer or oracle and shrines were dedicated to the python in hopes of a promise of divine help for human problems. Overall, though, the serpent has not fared well in its relations with mankind.

The cottonmouth moccasin, Agkistrodon piscivorus, *a common backwater and swamp dweller. This species is venomous and known to be aggressive.*

Dr. Dodd is a Staff Herpetologist with the Office of Endangered Species, U.S. Fish and Wildlife Service.

The Atlantic salt marsh snake, Nerodia fasciata taeniata, is a very rare species confined to salt marshes in Brevard, Volusia, and Indian River Cos. in Florida. It is threatened by habitat destruction and hybridization.
Photo by R. S. Simmons Courtesy U.S. FWS

Eurycea tynerensis, *a small neotenic salamander confined to streams and creeks in the Grand and Illinois River drainage system of the Ozark Plateau.*

Snakes are neither slimy nor, generally, cold to the touch. In fact, "cold-blooded" is a term that is most inappropriate for normally active reptiles. Although they cannot control the internal temperature of their bodies by physiological means, reptiles use behavioral methods to raise their temperatures to a preferred level so they can carry out daily activities. As a fishermen leaves the dock on his way to a favorite fishing hole, he often sees the heavy-bodied water snakes (*Nerodia* sp.) lying in the trees overhanging the water. These snakes use the outstretched limbs as "sun decks" where they will be safe from predators while they slowly drop into the water until the danger has passed, at which time they crawl back to the limb to continue warming. Basking also serves to increase the rate of digestive activity; thus, a snake that has recently eaten will lazily bask until the meal has assimilated. Prolonged "digestive" basking can continue from many days to weeks depending on the size of the meal.

Turtles are most commonly seen along rivers and streams where they bask either on logs or while floating in the water. As soon as light begins to filter onto the logs resting on water surfaces, river turtles (*Chrysemys* sp.) and (*Graptemys* sp.) begin to approach. But a turtle doesn't just climb onto a log and doze. Each turtle goes thru an elaborate ritual of swimming and surveying its basking site before cautiously leaving the water. Once settled, the "correct" position must be chosen and only the individual turtle seems to know what its correct position will be. In any case, the body is usually initially oriented in such a way as to maximize the heat received.

During the approach, the climb onto the basking site and initial orientation, turtles are most wary and will readily slip into the water should any hint of danger be sensed. Once settled, however, turtles lift their legs up in the air, extend the toes fully and begin a leisurely rest. Although a variety of reasons have been advanced for the limb extension, including drying the skin and synthesis of vitamin D from skin sterols via ultraviolet light, this behavioral pattern is probably related to thermoregulation. While dozing, turtles will yawn and snap at annoying flies but generally avoid much activity until their body temperature approaches their tolerated maximums. While

An alligator just breaking out into the world. Females usually lay 30-40 eggs in a well constructed nest which they guard.

An alligator nest in Charleston Co., S.C. This nest has been marked by the yellow flag so that it could be monitored closely.

basking, the body temperatures may reach as high as 40° centigrade, which is certainly not cold-blooded.

The apparent obliviousness to all but the most striking disturbance by some basking species, such as the Alabama red-bellied turtle *(Chrysemys alabamensis)* of the Mobile and Tensaw Rivers in Alabama, has led to a decrease in populations in many areas. Thoughtless individuals shoot these animals for "sport" when they can't find anything else to shoot. In addition to being shot at, big river turtles face injury from power boat motors as they bask while floating. As in the case of cars and highways, where ignorant individuals test their "manhood" by running down lumbering turtles crossing the road, certain individuals take delight in powering over turtles floating in the water.

When a species is harassed, shot at and has had its habitat reduced by development, it cannot maintain itself. It declines and eventually disappears. The Alabama red-bellied is one such species that has experienced drastic population reductions in recent years. Fortunately, people are beginning to recognize the plight of this species and are taking steps which will aid its survival.

The major threat, however, to the river turtles, especially those of the Southeast, does not come from periodic harassment from misguided individuals—it comes from the ever increasing destruction and modification of essential habitat. Nearly all the major rivers of the Southeast have been dammed or channelized or are slated for development in the form of waterways or more dams. As such, the continued existence of many unique species is jeopardized in ways not immediately apparent.

The map and sawback turtles, genus *Graptemys,* are one particular group of river turtles whose status has become of increasing concern to herpetologists. These turtles are almost exclusively confined to clear, clean, large rivers where they feed on molluscs and insects; small creeks and ponds are almost never used. Major modification of larger rivers disturbs these species in several ways. Because their diet consists largely of snails and crustaceans, the sawbacks disappear when rivers are dammed or channelized not so much because they are directly harmed as because their restricted food source declines or disappears. Increased siltation causes the elimination of snails and other molluscs because the gills become clogged and the guts become filled with nondigestible material. Siltation also destroys the riffle habitats and shoals where many aquatic insects are found.

When the food sources of the turtles disappear, their populations also decline because their rather rigid ecological requirements will not allow adjustment to the changed environment. Additionally, other species more adapted to the new environment or more generalist in their feeding behavior may colonize modified river ecosystems

and thus place additional pressure on the remaining specialists. Although stragglers may persist, eventually they too will be phased out.

Modification of stream and river channels has in many cases destroyed the habitat necessary for a major part of the life cycle of stream dwelling species—the beach where eggs are laid. All turtles, unlike some snakes, lizards, and many amphibians, lay eggs. These eggs are normally laid in spring on sandy, sunny, embankments where proper moisture and temperature conditions to allow successful hatching are ensured. When streams are modified, such nesting sites are eliminated and result in a population reduction of nearly all species.

In some cases, such as those of the Illinois mud turtle, *Kinosternon flavescens spooneri,* a major portion of the entire species nests on only one particular site. The last remaining significant population of the Illinois mud turtle could soon join the rapidly expanding list of known species which have become extinct as a direct result of man's activities. While the elimination of the Illinois mud turtle could be rapid, many other turtles face slow extirpation through the gradual elimination of nesting beaches.

Pollution is also a factor in the decline of many species of amphibians and reptiles. As human population increases, so do the pressures on river systems to serve industrial needs by carrying away refuse and waste material. When narrow ranges of temperature, organic material, oxygen and pH are breached, animal populations rapidly decline This may be because of direct negative side effects on some aspect of the life history of the species itself or on a prey species on which it depends. The hellbender *(Cryptobranchus alleganiensis)* was once relatively abundant throughout many of the large river systems of the East and Midwest. Today, this largest (to 3 feet) of our salamanders had been eliminated throughout much of its range, including the Ohio and Susquehanna Rivers, because of industrial pollution and lowered oxygen levels. When an environmentally sensitive species such as the hellbender is eliminated, it is an indication that the overall health of river systems is not good. While some species may persist, the overall diversity of life decreases and the resulting impoverished biota* is extremely vulnerable to catastrophic change.

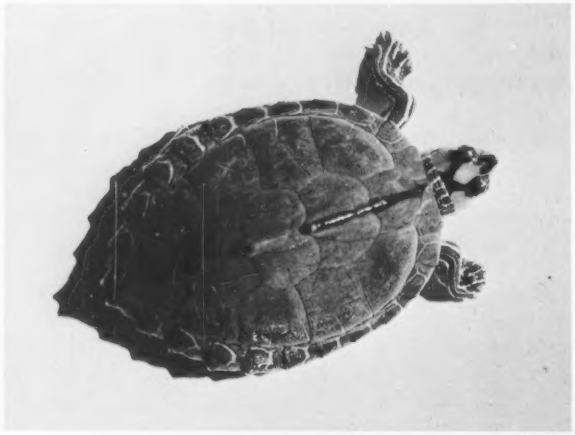
Many species of aquatic and semiaquatic amphibians and reptiles, like many fishes and fresh water mussels, are confined to limited ranges that may include only a single river system. Table 1 lists some of these species and their distributions. A case example of the problems faced by species with limited range would be that of the black-knobbed sawback *(Graptemys nigrinoda),* which historically was known from the Tombigbee-Alabama-Black Warrior River system in Alabama and Mississippi. This reclusive species has declined rapidly in numbers because of the impoundment of much of its habitat. Both the lower

*A specific region's total ecological entity.

An American Alligator from Alachua Co., Florida. Because of their dramatic recovery, the alligator has been reclassified as Threatened throughout much of its range.

A male Alabama map turtle, Graptemys pulchra. *This species is confined almost entirely to large rivers in Alabama and Mississippi. Although completely innocuous, it is often used for target practice.*

Photo by Dr. Roger Barbour



Tombigbee and the Alabama Rivers were impounded during the 1960s. Now, the upper Tombigbee and its major tributaries in Mississippi and the Cahaba River in Alabama provide the last remaining undisturbed habitat for this species.

At present, the extensive modification of the Tombigbee as the proposed Tennessee-Tombigbee Waterway will probably eliminate this turtle in much of the Tombigbee and bring it perilously close to the point where it cannot recover. The black-knobbed sawback has been included as endangered on a preliminary list of rare and threatened vertebrates by the Mississippi Rare and Endangered Species Committee in cooperation with the Mississippi Game and Fish Commission. In addition, this turtle has been included in a Notice of Review published by the U.S. Fish and Wildlife Service as a species which may be either endangered or threatened as a result of past or proposed extensive habitat destruction.

One possible bright spot for the sawback is that the Cahaba River is currently under study for inclusion in the National Wild and Scenic Rivers system.

River modification produces mixed effects for differing species of amphibians and reptiles. While river channels and banks may be extensively altered, impoundment often produces much backwater area which may be conducive to the likes of some frogs and slow water turtles. It may be a mixed blessing for Southeastern fishermen and property

The painted turtle, Chrysemys picta, *is one of the best known of all water turtles. It is found throughout much of the United States.*

owners bordering such impoundments since backwater areas are a favored habitat of the cottonmouth moccasin, a large venomous and aggressive snake. A recent Corps of Engineers report on the Tennessee-Tombigbee Waterway indicated that cottonmouths might increase considerably in numbers should the waterway eventually be completed.

Ranging from North Carolina to Texas and north at least as far as Arkansas and Oklahoma is a large beast whose Chinese relative apparently gave rise to the legendary dragons of the Far East. It is the alligator, a corruption of the Spanish "el lagarto". Long considered a menace, a source of hides and, to a much lesser extent, meat, the alligator had experienced severe population declines throughout its range to the point that it was faced with extinction. Consequently, the Department of the Interior classified the species as endangered under the provisions of the Endangered Species Act of 1973 and enforced the strict regulations of the Act, especially those regarding interstate and foreign commerce, to protect this species. Federal protection was supplemented by State laws and the alligator began to recover.

Alligators are prolific; the females lay 30 to 40 eggs in a nest constructed of vegetation. Since the female guards the nest against intruders, nest predation is probably low. When the young are about ready to hatch, they emit a high pitched squeak and the mother responds by opening the nest with her jaws.

Parental care is virtually unknown in amphibians and reptiles and was long disputed for crocodilians. However, it is now well documented that the mother alligator does aid the young by transporting them to water in her mouth. The young also remain for some time in the vicinity of the nest where, if alarmed or threatened, they again emit their squeak to which the mother and perhaps other adults respond. Nest protection, combined with a degree of parental care and protection from hunting, allowed the alligator to increase significantly in numbers.

Increased study of the habits and ecology of alligators, largely as a result of protective measures, also made scientists aware of other unique features of the alligators' life history. For instance, males court females in an elaborate display of swimming, posturing and stroking. Females take great care both in shaping the nest and opening it at hatching time. Also, alligators appear to engage in play behavior.

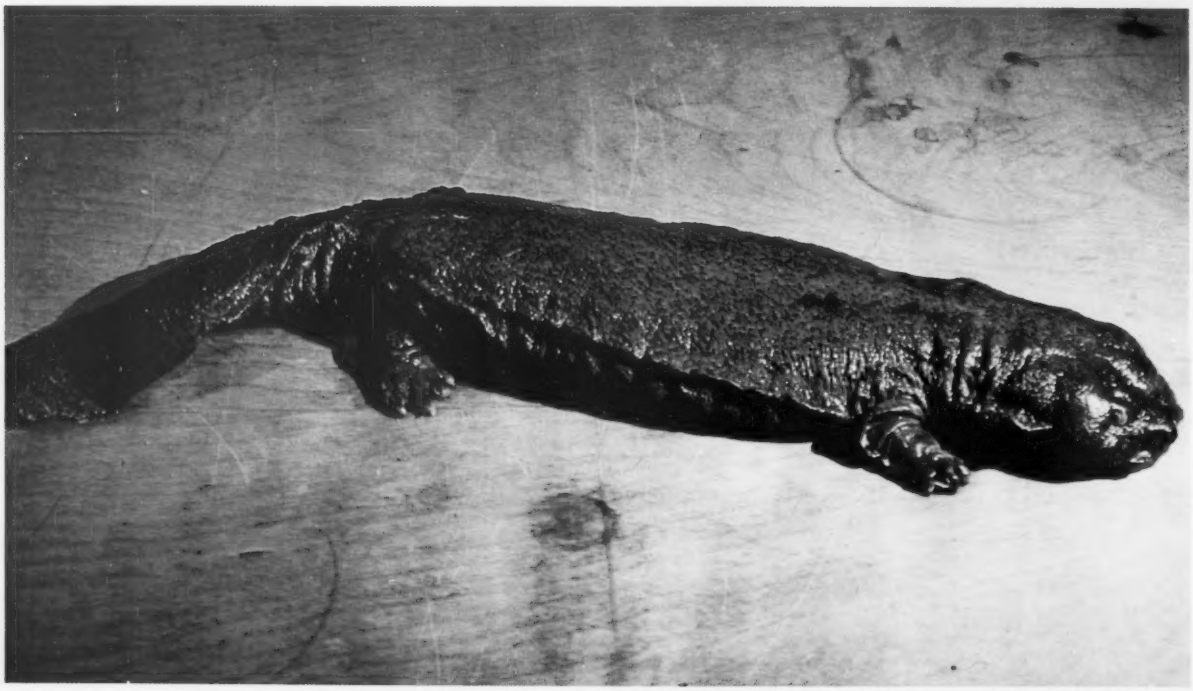
Conservation also stimulated research into the management of alligators which has proved particularly successful, especially in the State of Louisiana.

Today, the status of the alligator looks much improved. Although still considered endangered in some parts of its range, it has greatly increased in numbers to the point where some have lost their fear of man and become nuisances, especially around ponds in developed areas. When such nuisance alligators are encountered, they are

A slow moving "blackwater" stream in southern Mississippi. The white sandy beaches are preferred nesting sites for many species of freshwater turtles.

The Neuse River in North Carolina. Along with the nearby Tar River, this is the only known habitat of the Neuse River waterdog, Necturus lewisi.

An adult hellbender, Cryptobranchus alleganiensis, *from South Carolina. Because this species prefers clean, well oxygenated waters, its presence is an indication that a stream is healthy.*



An Atlantic salt marsh, home of a number of uniquely adapted water snakes which have adapted to a saline environment.

usually trapped and moved to remote regions where they cannot get into trouble; only rarely are pest alligators shot. Some areas, especially in Louisiana, have experienced alligator increases large enough to allow limited State-regulated hunting in cooperation with the Fish and Wildlife Service. The alligator must still be strictly protected to prevent illegal trade and other abuses which can rapidly again lead to a precarious status.

Education programs must still inform the public about its conservation, its value, the dangers associated with it, and its role in the maintenance of its ecosystem. For instance, the alligator is known to be extremely important in the existence of many species which dwell in an aquatic environment in the Everglades of Florida. Adult alligators build "gator holes" throughout the grasslands. When the dry season comes, these gator holes serve as refuges for aquatic species until the rains return; thus they are vitally important in the Everglade's ecological balance.

In addition, many individuals now recognize the alligator as a valuable predator and are trying to obtain them to control pest species, such as beavers. The alligator story is an example of how endangered species can be managed successfully if proper time, understanding and care is taken.

The alligator has one relative in the continental U.S., although it is only peripheral. This is the American crocodile, *Crocodylus acutus,* of the lower Florida peninsula. Although superficially very similar to alligators, the American crocodile has a more pointed snout and, as an adult, seems to prefer salt water and estuaries as opposed to the alligator, which lives in fresh waters.

The crocodile nests on sandy beaches on certain keys and, to a limited extent, in southern Florida. The modification of this area, due to urbanization, increased usage for recreational purposes and channelization, has led to the reduction of the Florida population. This reduction is apparently due to both the gradual elimination of breeding adults and the lack of recruitment of young to the adult population. The modification of rivers in the lower Florida area has allowed for an increase in the runoff of fresh water into the estuaries. Young crocodiles cannot survive full strength salt water in the early stages of life while those raised in fresh water cannot later adjust to salt water which the adults prefer. As a result, few young crocodiles now survive to adulthood, and the present population tends towards older individuals. The American Crocodile Recovery Team of the Fish and Wildlife Service is currently monitoring this situation.

Habitat modification, particularly in the form of dredging and filling of coastal marshlands, has had other effects on reptiles besides directly destroying ecological balance and favorable habitat. For instance, the coast marsh water snakes are a unique group of snakes adapted to salt marshes from North Carolina to Texas. Although closely related to fresh water species, the salt marsh snakes are specially able to exist physiologically in an environment which reptiles have seldom mastered.

Because of the inhospitable nature of the environment (mud, muck, mosquitoes, etc.) little is known of even the basic life histories of these species. The Atlantic salt marsh snake *(Nerodia fasciata taeniata)* is one such species.

Unfortunately, the modification of the salt marshes has led not only to direct habitat destruction but also to the breakdown of the ecological isolating mechanisms which in the past have kept the Atlantic salt marsh snake and its closely related fresh water counterpart from interbreeding. Habitat modification allows these species to intermingle and breed, thus destroying the unique genetic identity of the restricted in range and physiologically interesting salt marsh species. The breakdown in ecological isolating mechanisms because of habitat destruction, resulting in hybridization, is also known in other groups of amphibians and reptiles, including toads and lizards.

Currently, many States are reassessing their attitudes toward nongame animals and are developing laws and programs designed to enhance the survival of many previously neglected species. In addition, Federal protection in the form of the Endangered Species Act of 1973 now covers 15 species of amphibians and reptiles and has been proposed for 14 more. The Fish and Wildlife Service is also actively monitoring the status of all amphibians and reptiles in the hope of preventing the decline of any of our native herpetofauna.

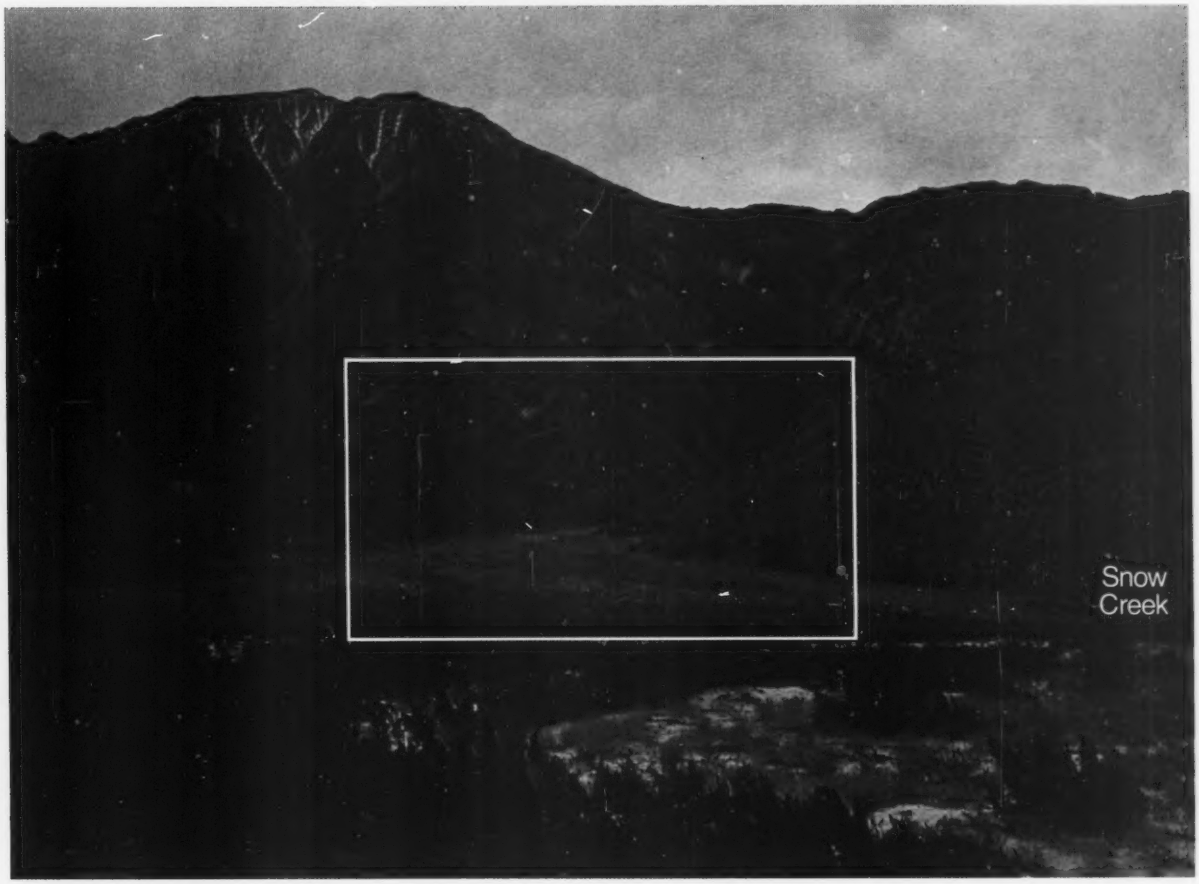
With increasing understanding of the importance of amphibians and reptiles and their unique habitats, an important part of the natural heritage of our country can be maintained. The important thing is to care. ■

A gravel operation on the Pearl River in Mississippi. Such large scale river alteration destroys much habitat available to amphibians and reptiles; the affects are felt far downstream from the gravel operation.

An albino larvae of the marbled salamander, Ambystoma opacum. *The gills which obtain oxygen from the water are readily apparent. This species uses temporary ponds to breed; if these ponds are destroyed, the species disappears.*

A shoal and riffle area on the Tombigbee River in Mississippi. Many food items, such as crustaceans, insects, and molluscs, of sawback turtles, like the black-knobbed sawback, depend on these shoals for their continued existence. Logs provide good basking sites.

Approaches to 'Plain' Problems



Community of Snow Creek, far right, is comparatively free of flooding due to its peripheral position on the fan.

by **David L. Gundlach**

An alluvial fan (plain) is an accumulation of sediment deposited by flowing water at the mouth of a canyon (or ravine) and is characterized by continually changing channel patterns and locations of deposits. This nomadic feature of fan plains poses problems for engineers trying to predetermine flood hazard areas, develop damage reduction programs and make informed land use decisions. (The author confines his specific examples to California projects).

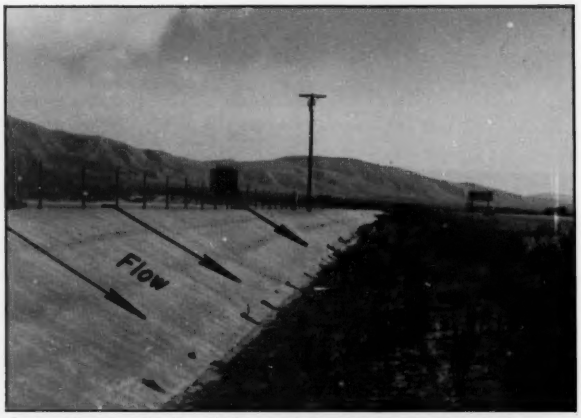
A major national effort is underway to document those areas subject to frequent flooding. Once the specific land areas prone to flooding are delineated, strategies can be developed to reduce flood losses—such as State statutes, local ordinances, flood-insurance rates and flood-control structures. For riverine areas, where the river channel's geometry and location are relatively stable, conventional methods of flow analysis usually produce workable data. However, conventional flow analysis is not adequate for those areas of the United States with stream beds that are immature or that transport high loads of debris and sediment.

Although those unstable types of channel configurations are most prevalent in the mountainous areas of the West, similar conditions exist elsewhere and recently scores of people died as a result of mudslides in very steep areas of Virginia. Also, meandering streams, common to the flatter Midwest, pose many of the same problems as the alluvial fans deposited by runoffs in the mountainous western states.

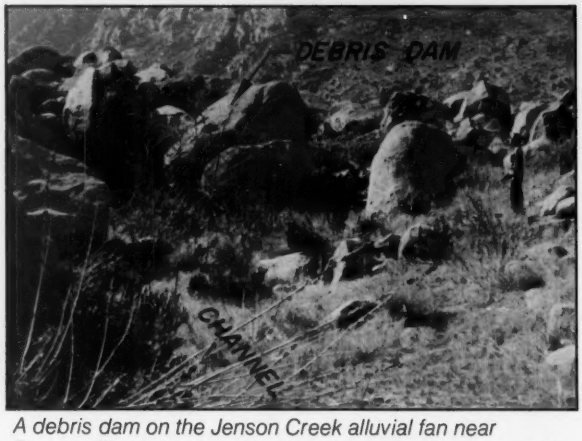
The most troublesome feature of fan development is its inherent tendency to alter both the channel pattern and location of debris deposition after each flow. Changes in the channel geometry may occur slowly, in which case the alluvial material is alternately transported and deposited progressively farther from its sources with each successive flow. During extremely high flows these changes tend to occur more rapidly.

The problem faced by those who need to determine the flood hazard areas with an eye toward flood damage reduction programs and land use decisions is that each significant flow on an alluvial fan produces a change that may drastically alter the flooding potential of subsequent flow events. These changes arise largely from the fact that boulders, debris or mud flows may partially or completely block existing channels, diverting flood waters into overbank areas and cause substantial change in flow patterns than would normally have occurred. Obviously there are numerous ways in which deposition or channel erosion could alter future flooding patterns but, in essence, two conditions need to be emphasized: One is channel blockage; the other is major debris flow deposition.

The author is a hydraulic engineer at the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California.



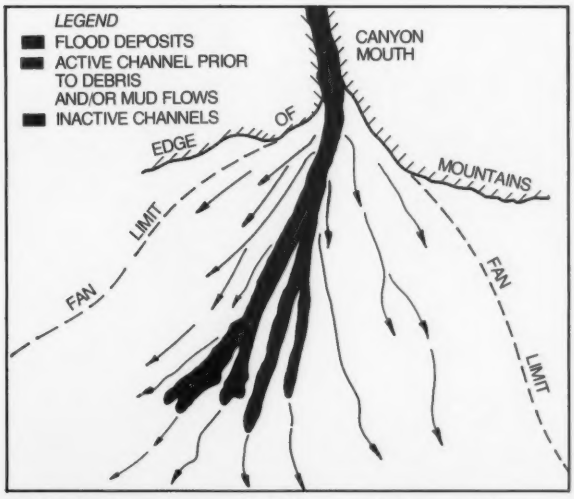
Lateral concrete-lined channel has been constructed across Millard Canyon alluvial fan near Cabazon to intercept flood flows.



A debris dam on the Jenson Creek alluvial fan near Banning illustrates the size of boulders blocking one of the active channels.

Channel Blockage

Channel blockage is the damming of an existing alluvial fan channel. It usually occurs when large boulders, tree trunks and other relatively large objects become lodged behind constrictions in the channel. Such blockage occurs more frequently on alluvial fans having large boulders and/or extreme channel constrictions. Debris dams often result from the undercutting of banks by erosion, causing masses of alluvial material to sluff off and block part or all of a given channel. (These are nature's debris dams, which



Typical pattern of deposits left by a debris or mud flow on an alluvial fan.

Shifting flood flows destroyed this house on Stubbe Canyon near Palm Springs. At the time it was built the now-abandoned structure was some distance from the nearest active channel.

occur during periods of high flows. They should not be confused with engineered structures designed to capture debris moving downstream). Channel blockage, depending on its extent, can cause subsequent flows to spread out or divide laterally, inundating substantially larger areas of the fan surface. A thorough field investigation is necessary to determine the possibility of their occurrence.

The second condition to consider is the likelihood of deposition due to a *major* debris flow. This condition may have a greater effect on the total area subject to future flooding than more gradual deposition or erosion resulting from several smaller flows occurring over a longer period.

A major debris flow can significantly reduce or even eliminate the capacity of particular reaches of both immature and older channels to convey flood waters.

The possibility of a debris flow depends upon the magnitude of runoff in the drainage basin, particularly within the trunk canyon and its immediate adjoining areas. The actual deposition pattern can be estimated or modeled to some degree based on past research.[1,2,3] In general, debris flows adhere closely to the underlying topography, which means that the depositions usually occur within or adjacent to the *active* main channel. Wherever the active channel becomes too shallow, however, debris flows tend to spread out and to follow one or more of the older channels.

The buildup of debris within the active channel and adjacent areas due to major flows can be approximated in advance. In making such an approximation, the planner can assume there has been a single flow of such magnitude that a large percentage of the erodible material available (or potentially available at some later date) has been removed from the source area and deposited on the fan surface. The results can then be used to modify topographic maps prior to reevaluating the flood plain under study.

However, if a major debris flow has recently flushed most of the erodible material from the source area, it may be years before sufficient material can accumulate on the canyon floor to develop another large debris flow. In such a case, succeeding events would consist primarily of flows with small sediment loads and a period of rechannelization on the fan surface would follow.

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[1]John E. Kesseli and Chester B. Beaty; *Desert Flood Conditions in the White Mountains of California and Nevada*. Headquarters Quartermaster Research & Engineer Command, US Army, Technical Report EP-108, Natick, Mass., April 1959.

[2]Chester B. Beaty; Sequential Study of *Desert Flooding in the White Mountains of California and Nevada*. Technical Report 68-31-ES, Natick, Mass., 1968.

[3]William E. Price; *A Random-Walk Simulation Model of Alluvial Fan Deposition*. Technical Reports on Hydrology and Water Resources, Technical Report No. 7 University of Arizona, Tucson, Arizona, June 1977.

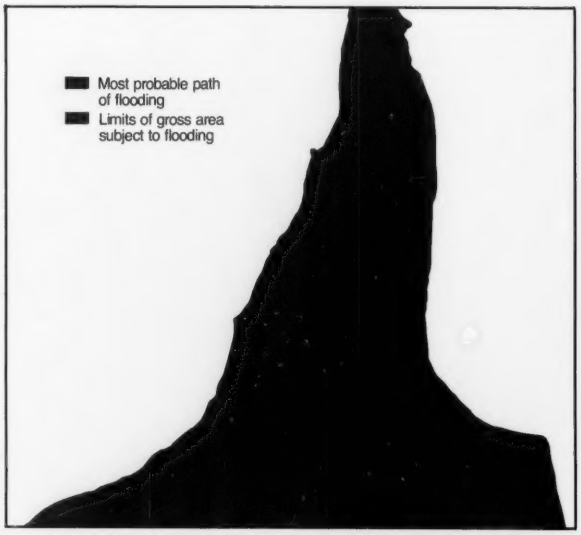
A flood plain analysis of alluvial fans should logically follow two steps: (1) Determine the area subject to possible flooding under existing conditions and (2) determine the potential flood plain after allowances have been made for deposition and erosion which could reasonably be expected to occur in a designated period of time. Consider the alluvial fans in the San Gorgonio Pass area of Riverside County, California, for example. Assuming a *water-flow* event, the most probable flow paths and respective overflow areas were determined for what hydrologists refer to as the computed 100-year flood, or that flood with a 1 percent chance of occurring in any year. Then simulating probable combinations of channel blockage and/or major debris deposition, the area subject to flooding due to the 100-year *water-flow* event was recomputed. Figure 1 shows the gross area subject to possible flooding by combining the results of steps 1 and 2.

Land Usage

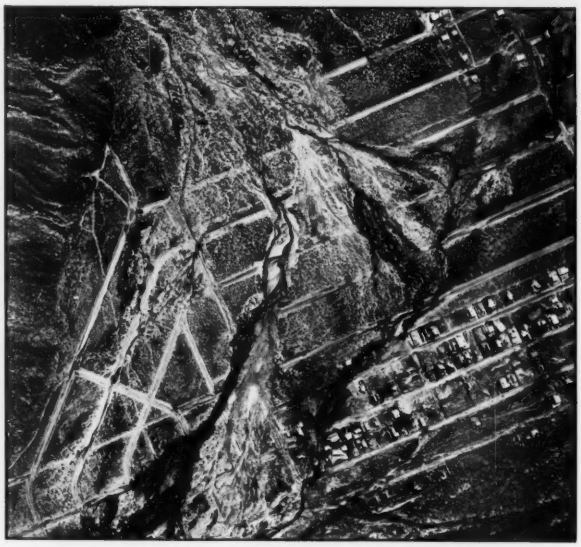
Since flood flows could possibly become concentrated anywhere within the gross area subject to flooding (such as shown in Figure 1), future land usage must be carefully planned to avoid or at least reduce possible flood damages. As an example, the community of Snow Creek was built on an alluvial fan, but its peripheral location adjacent to the base of the fan surface leaves that community comparatively free of flooding. The development shown in Figure 2, however, was built across the base of an alluvial fan and is highly susceptible to major flood events. In both cases, the location of these communities on the milder slopes near the valley floor reduces their vulnerability to the potentially destructive force of high velocity future flows.

Up to now, flood-control structures intended to prevent or reduce flood damages on alluvial fans have consisted primarily of levees and channels that intercept, confine and divert flood waters. Since fan surface flows tend to spread out wherever the active channels become inadequate, structures such as interceptor channels need to be designated based on the gross area that might be flooded at some later date.

Flood waters on the Snow Creek alluvial fan, for example, are directed toward one side at the very apex of the fan due to the channel alignment near the canyon mouth. In this case, flood waters directed toward the opposite side of the fan surface reduced the possibility of major flooding for the downstream community of Snow Creek.



Predicted flood area on upper part of Jenson Creek alluvial fan due to 1-percent chance flood.



The erratic flow patterns of the 1969 flood damaged this subdivision located at the base of the Jenson Creek alluvial fan. This development remains highly susceptible to future flood flows.

Banning is partly visible beyond earthen levee constructed on upper part of alluvial fan to contain and divert flood waters around the city. A gabion barrier (rock-filled wire baskets) protect toe of levee from erosion by San Gorgonio flood flows.

Levee and channel on Chino Canyon alluvial fan provide flood protection for existing development in Palm Springs.

In another case, the levee completed in 1965 to protect the 13,000 inhabitants of the city of Banning, (Figure 3) is designed to contain the *standard project flood*.[4] This levee averts possible flooding of the city, which is in a direct line with the San Gorgonio River flood flows issuing from the canyon mouth onto the broad coalescing alluvial fans at the foot of the San Bernardino Mountains. Eventually, the continuous processes of erosion and deposition would have caused flooding were it not for the presence of the earthern levee that confines and diverts flood waters around the eastern part of the city. The magnitude of these flows has made it necessary to protect the levee from further erosion by clearing and excavating the existing channel (in the immediate vicinity of the levee) and constructing a gabion barrier along the greater part of the levee's toe.

The flood control project for the Chino Canyon alluvial fan (Figure 4) was also designed to contain the standard project flood. It consists of 3.4 miles of levee and 1.6 miles of excavated channel. In essence, this project could contain a major debris flow followed by a water-flow of the magnitude of the computed standard project flood. This means that even if the debris flow partially or completely filled the excavated channel and adjacent areas with debris, the levee, as designed and constructed, would still contain subsequent flood flows (water flows) up to the size of the standard project flood.

As the upper right corner of Figure 4 shows, development has taken place on the fan surface in areas formerly susceptible to flooding. The Chino Canyon Project provides flood protection not only for these areas but also some 9,000 acres of valuable property in the nearby city of Palm Springs.

Other measures that could prevent or reduce flood damages on alluvial fans include zoning ordinances, encroachment regulations, and governmental acquisition of flood-prone lands. Flood insurance can lessen post-flood losses. Each of these, of course, relies on the proper delineation of flood hazard areas based in reference to a 100-year flood. In this respect, the alluvial fan is no different from any other flood plain.

No one event is likely to inundate all of the flood hazard area as designated within a Corps of Engineers flood plain information report. Even so, a proposal to use the total flood hazard area to designate the probable floodway for the 100-year flood event is being considered. The effect would be to extend the flood plain's boundary to cover a much wider area than that actually susceptible to any single flood. All of the area, however, could possibly be flooded at some time in the future. The shifting channels typical of alluvial fans tend to add immediacy to the need for a broader definition of flood hazard areas. ■

[4] A flood caused by the most severe combination of meteorologic and hydrologic conditions considered reasonably characteristic of the geographic area in which the drainage basin is located. It excludes extremely rare combinations.

RIVER QUALITY CASE STUDY: THE WILLAMETTE

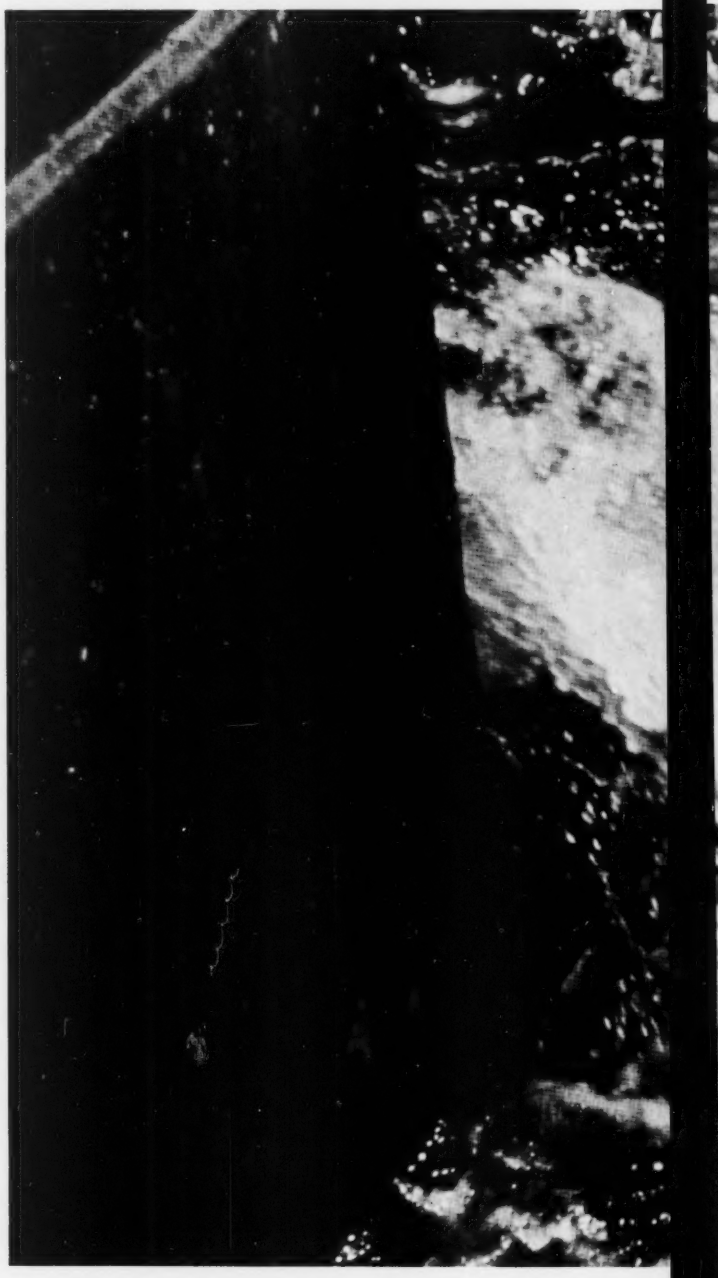
by **Bob Norton**

Comprehensive river quality assessments are critically needed in most areas of the country today, and their absence leaves water resources planners and managers faced with major decisions on wastewater treatment without the benefit of adequate background data. Achievement of desirable river quality at acceptable cost requires that these far-reaching decisions be based on sound information, not whims.

Problems confronting river basin managers are nearly universal: Population growth and its resultant increased discharge of wastes affects dissolved oxygen contents; increasing nutrient loading encourages excessive algal growth; potentially toxic materials accumulate in river bottom sediments; and riparian erosion intensifies in proportion to increased demands for land use. Unfortunately, sound evaluation of such problems is generally difficult because there is a paucity of relevant assessment data, and a lack of nationally adaptable methodologies for quality assessment studies. (Fig. 1)

With the latter in mind, the Department of Interior recommended that the U.S. Geological Survey undertake an interdisciplinary, pilot river quality study to provide the framework needed for future assessment of river basins throughout the nation. In January 1973, the Survey responded by initiating a 2½-year prototype assessment of Oregon's Willamette River.

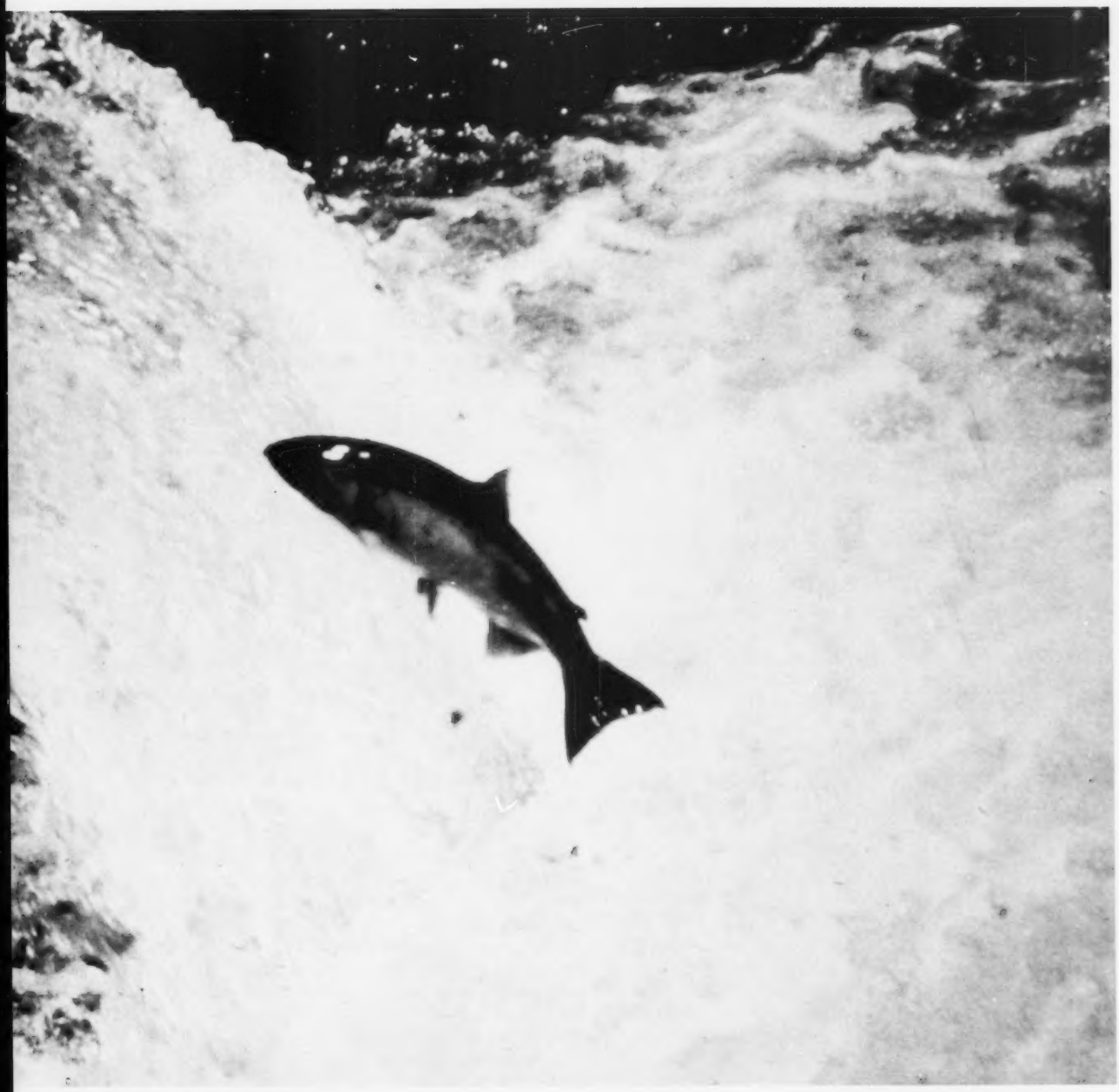
The Willamette River Basin, with a watershed of nearly 11,500 square miles, encompasses the state's three largest cities—Portland, Salem and Eugene, and approximately 1.4 million people, or about 70 percent of the state's 1970 Census population (Fig. 2). The basin supports an economy based on timber, agriculture, industry and recreation, and supplies extensive fish and wildlife habitats. It is roughly rectangular, with a north-south length of about 150 miles and an east-west width of 75. Elevations vary from less than 10 feet near the Willamette's mouth to 450 feet on the valley floor at Eugene and to more than 10,000 feet in the Cascade Range headwaters. Average annual precipitation in the basin is 63 inches.

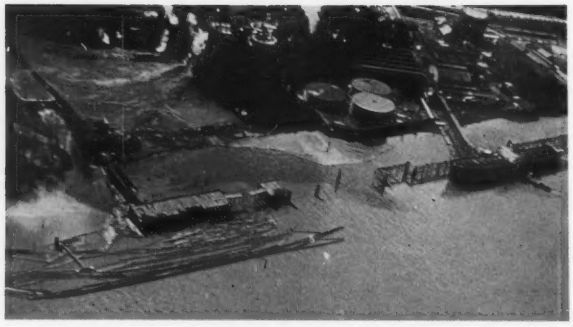


Geologic Overview

On the basis of physiography and geology, the Willamette River Basin can be divided into three north-south provinces:

Bob Norton is the new editor of Water Spectrum. This article is adapted from U.S. Geological Survey Circular 715-M, by David A. Rickert et al.





Willamette River, Portland harbor area, about 1955, depicting noticeable water pollution.

The Cascade Range, the Coast Range, and the interlying Willamette Valley.

The mountains and foothills of the Coast Range are formed largely by volcanic and marine sedimentary rocks. The older volcanic rocks, consisting of basalt flows and volcanic debris, are interbedded with continental sedimentary rocks. The marine sedimentary strata consists of sandstone, shale, and mudstone.

The Willamette Valley is an elongated alluvial lowland framed by resistant volcanic and sedimentary rocks, with much of the valley covered by sandy to silty terrace deposits derived from the surrounding mountains. The main stem of the Willamette is formed by the confluence of the Coast and Middle Forks near Eugene, and flows for 187 miles to its convergence with the Columbia near Portland. Over this distance the channel bed drops from an elevation of 435 feet to slightly below mean sea level (Fig. 3).

The main stem comprises three distinctive reaches whose physical characteristics govern the hydraulics of flow and therefore the patterns of deposition, channel scour, and sediment transport.

The Upstream Reach, extending for 135 miles from Eugene to above Newberg, is characterized by a meandering channel. The river is shallow and the bed is composed almost entirely of cobbles and gravel, which, during summer, are covered with biological growth. During low-flow conditions, average stream velocity is about seven times that of either of the two downstream reaches. During floods, velocities are sufficiently high to transport large quantities of cobble and gravel as bedload. Morphologically, this upstream reach of the Willamette is an ''eroding'' reach.

The Newberg Pool extends for 25.5 miles from above Newberg to the Willamette Falls. Hydraulically, the deep, slow-moving Pool can be characterized as a large stilling basin behind a weir (Willamette Falls). As evidenced by the elevation profile in Fig. 3, its average low-flow velocity, and the presence of fine bottom sediment, the Pool is a depositional reach.

The Tidal Reach, covering the lower 26.5 miles of the river, is affected by tides and, during spring and early summer, by backwater from the Columbia River. The Tidal Reach is extensively dredged to maintain a 40-foot deep navigation channel from the mouth to about river mile (RM) 14. During the summer low-flow period, net downstream movement is slow, but tidal effects cause flow reversals twice daily and resultant changes in velocity. Low flow hydraulics are most complex in the lower 10 miles where, depending on hourly changes in tide- and river-stage conditions, Willamette River water may move downstream, or Columbia River water may move upstream. Owing to morphological characteristics and hydraulic conditions, the subreach between RM's 10 and 3 is the primary depositional area of the entire river system.

Reservoirs and Streamflow Patterns

There are 11 major reservoirs in the Willamette River Basin with a combined usable capacity of approximately 1.9 million acre-feet. The reservoirs are designed for multipurpose use, but their primary function is flood control. Another important conservation purpose is the maintenance, during summer, of a minimum navigable depth in the Willamette River. Other uses include power generation, on-site recreation, maintenance of adequate streamflow for anadromous fish propagation, irrigation, and flow augmentation for water quality enhancement. The latter use is not explicitly planned but occurs as a result of summertime releases made for other purposes.

Reservoir regulation has had a profound impact on low flows, with marked increases occurring in the 1-, 3-, 7-, 14-, and 30-day low flows during the post-1953 period. Reservoir regulation has also curtailed the length of the low-flow period, typically from about mid-July through mid-October before regulation, to about mid-July through mid- or late-August following regulation. This condition occurs because the reservoirs, as recently operated, release extra water in the early fall to enhance anadromous fish runs.

Assessment Framework

The Willamette was selected for the prototype assessment study following nationwide river basin comparisons within three vital parameters: It is the **largest** U.S. river on which **all** major point source municipal and industrial discharges receive secondary wastewater treatment. Additionally, during summer low-flow periods, it receives releases from its 11 reservoirs and thus provides for an ideal **comparison of wastewater treatment and flow augmentation as dual means for achieving desirable river quality.** Thirdly, the Willamette was selected because of the **availability of formal basin-management plans and several land use projections.**

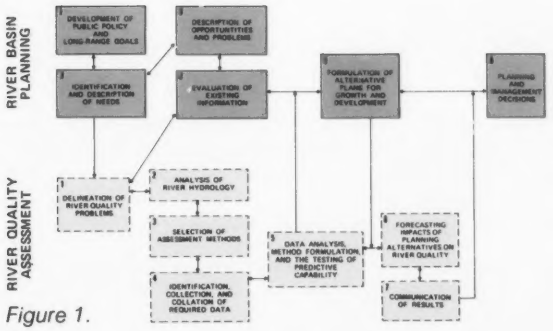

RIVER BASIN PLANNING
RIVER QUALITY ASSESSMENT
1 DEVELOPMENT OF PUBLIC POLICY AND LONG-RANGE GOALS
2 DESCRIPTION OF OPPORTUNITIES AND PROBLEMS
3 IDENTIFICATION AND DESCRIPTION OF NEEDS
4 EVALUATION OF EXISTING INFORMATION
5 FORMULATION OF ALTERNATIVE PLANS FOR GROWTH AND DEVELOPMENT
6 PLANNING AND MANAGEMENT DECISIONS
1 DELINEATION OF RIVER QUALITY PROBLEMS
2 ANALYSIS OF RIVER HYDROLOGY
3 SELECTION OF ASSESSMENT METHODS
4 IDENTIFICATION, COLLECTION, AND COLLATION OF REQUIRED DATA
5 DATA ANALYSIS, METHOD FORMULATION, AND THE TESTING OF PREDICTIVE CAPABILITY
6 FORECASTING IMPACTS OF PLANNING ALTERNATIVES ON RIVER QUALITY
7 COMMUNICATION OF RESULTS

Figure 1.

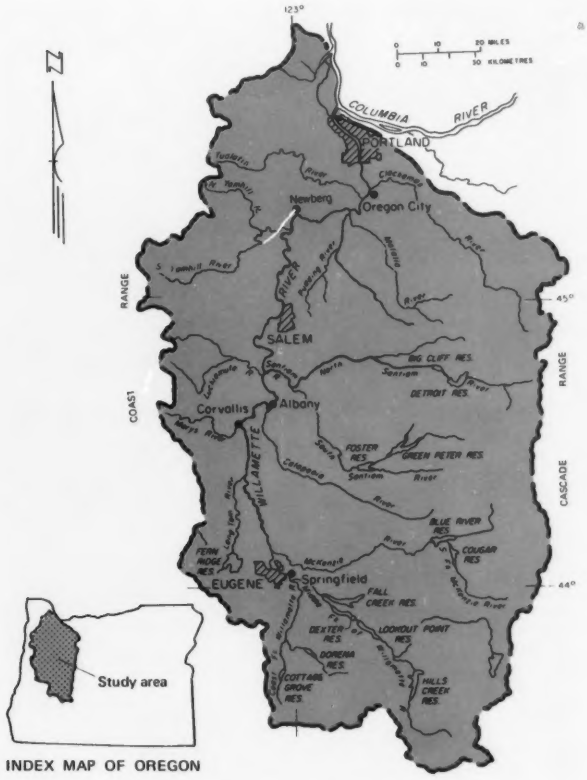


Figure 2. – Willamette River basin, Oregon.

It was determined that the study team should include disciplines in hydrology, sanitary chemistry, aquatic biology, mathematical modeling and geology.

Specific work elements for the program were determined through discussions with State, Interstate and Federal agencies concerned with the management of river quality. Discussions proceeded over the first four months of the project to identify eight existing or potential river quality problems (Table below):

Existing or potential river-quality problems of the Willamette River Basin, Oregon

Problem	Relative Importance[1]	Selected for study
Nonpoint-source pollution	3	
Reservoir-release quality	3	
Dissolved-oxygen depletion	1	X
Algal-problem potential	2	X
Trace-metal occurrence	1	X
Sanitary quality	3	
Accelerated erosion	1	X
Riverbank esthetics	2	

[1] 1=greatest importance; 3=least importance

Selection of project elements for this pilot assessment was accomplished by analyzing the priority list in terms of ability to produce useful information within the constraints of time, funding, and manpower. All three priority 1 problems were selected as project elements, and the priority 3's rejected. On the basis of manpower considerations, "algal-problem potential" was selected over "riverbank esthetics."

The study group used a seven-step iterative process in reaching the overall goal of providing a practical approach to nationwide river quality assessment (Fig. 1):

- ☐ Determine existing and potential river quality problems
- ☐ Analyze river hydrology
- ☐ Select and develop assessment methods
- ☐ Identify, amass and collate pertinent data
- ☐ Analyze data and formulate methods to enable prediction

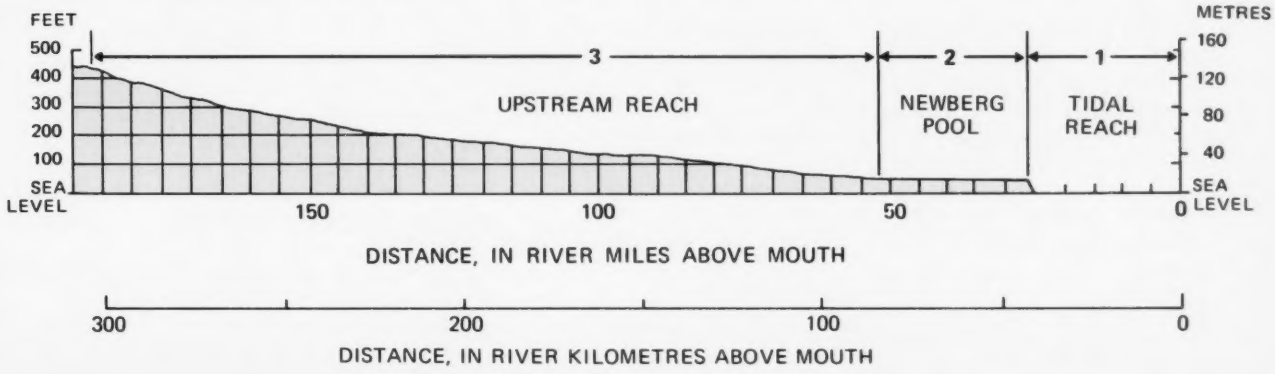


Figure 3. – Willamette River, Oreg., Elevation profile

- ☐ Forecast impact of resource management alternatives
- ☐ Communicate results to resource planners and managers and the public

Study Methods/Results

For the Willamette, three study methodologies were eventually chosen, each particularly suited to one of the "universal" river quality problems mentioned earlier.

Mathematical modeling was settled upon to address and quantify the cause-effect relationships of dissolved oxygen (DO) depletion. Historically, severe DO depletion during the summer has been the critical river quality problem on the Willamette. In recent years, summer DO levels have increased dramatically, and this is the result of secondary biological treatment of all point-source wastes and of streamflow augmentation from storage reservoirs.

Mathematical modeling works as a satisfactory study method for DO problems because a sound theoretical and empirical basis exists for writing the equations and the data required for calibrating and verifying a practicable, reliable model can be collected. Mathematical models are usually preferable to other methods of studying DO problems because they are capable of providing the most quantitative analysis of critical relationships. They, therefore, represent the best available approach for predicting the possible impacts on DO of alternatives for future river-basin development. The predictive ability is essential, because, at present, DO is the most important characteristic for managing quality in the majority of the nation's rivers.

Past decision makers have often mistrusted DO mathematical models as many have been formulated from insufficient data and/or ineffectively applied to potential planning and management decisions. The Willamette study team, to circumvent this bias, established the following guidelines:

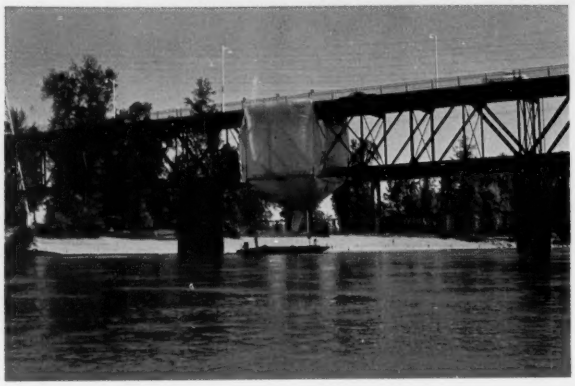
- ☐ Select the simplest mathematical configuration capable of providing useful planning and management information;
- ☐ Model only the critical time period and river reaches of DO depletion;
- ☐ Calibrate the model against one set of data and later verify it against a second set of completely new data;
- ☐ Conduct an intensive data collection program to provide the needed data;
- ☐ Present all modeling results in an easy-to-understand format.

The results of the model[1] indicated that reliance on point source treatment, without low flow augmentation, is inadequate for DO maintenance in the Willamette, even if the treatment state-of-the-art is improved. Future achievement of DO standards in the Willamette River will require continued low-flow augmentation in addition to pollution control.

Interpretive mapping[2] was used to define the critical interrelationships between land-use, terrain properties, and erosion problems. The procedure was premised on the fact that climate and terrain properties and land-use activities result in varying types and severities of erosional-depositional problems.

The procedure was to first produce an erosional-depositional province map and then to prepare an erosional-impact matrix for direct use by basin planners. At the outset, an up-to-date photomosaic base was needed at a scale suitable for recognition of natural and altered surface-cover conditions. In response, the mosaic was prepared from high al-

Industrial water pollutants enter and mix with Willamette River, forming noticeable interface between waste discharge and natural river conditions.



Bridge over Willamette River at Salem, Oregon. Notice catch-bag draped over bridge structure to capture paint chips before they can fall into the river.

titude photographs taken by the U.S. National Aeronautics and Space Administration (NASA) in July 1973, at a scale of 1:130,000. Regional physiographic divisions mentioned earlier under geologic overview were further subdivided for better definition of erosional cause-effect phenomena and for application to environmental planning. The investigated factors were vegetation, precipitation and runoff, soil, geology and terrain slope.

The hypotheses for evaluating these factors were tempered by four overriding considerations: (1) the primary objective of the study as a regional overview of the major processes and problems of the sediment system, rather than as a comprehensive geomorphic investigation suited for site-specific interpretations, (2) the need for a simple, practical product

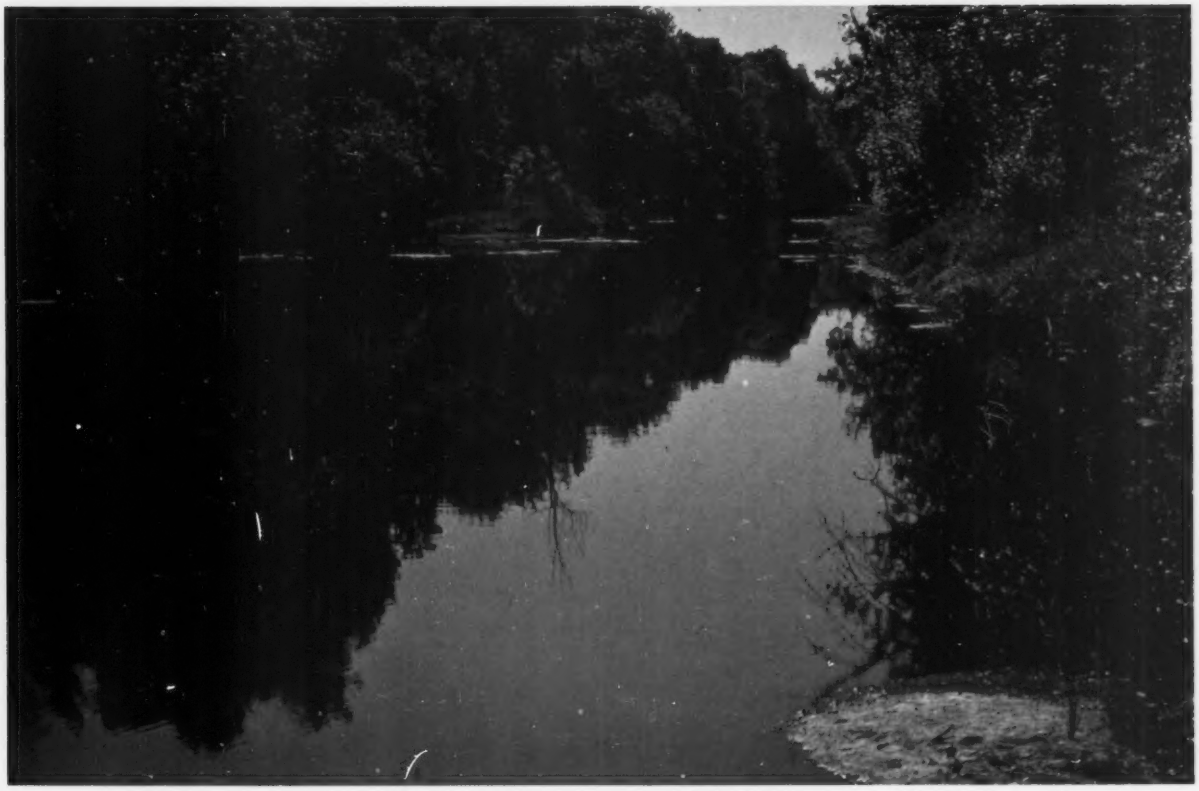
[1]The basic model used was the Velz Model. The program formulated therefrom is called the WIRQAS (Willamette Intensive River Quality Assessment Study Model).

[2]Derived from approaches used to delineate erosional problems in the San Francisco Bay area (Brown and Jackson, 1973 and 1974).

that is understandable by planners and compatible with the 1:130,000-scale photomosaic base, (3) the large variance in quality, quantity, and scale of existing earth-resource data and maps, and (4) the extensive background of observations, publications, and knowledge concerning the functions, relationships and relative importance of the major factors affecting the sediment system.

With the investigative factors overlayed on maps that delineated six separate erosional and two depositional provinces of the Willamette Basin, a basic tool existed for exami-

Conser Slough, an oxbow lake emptying into the Willamette River near Albany, Oregon.



nation of the basinwide condition of the sediment system. However, the map's utility for environmental planning was augmented through development of an erosional-impact matrix, and the study group now had a means for making tentative estimates of the erosional impact of human activities on various lands in the basin.

The following sequence provides a guide for using the map and matrix:

(1) **Locate** the parcel of land for which a particular activity or combination of activities, has been proposed.

(2) **Identify** the province in which the proposed activity would occur and examine the prevailing patterns of land-use and erosional features for indications of the possible magnitude of erosion that would be caused by the proposed change in land-use activity.

(3) **Note** the prevailing geologic and slope conditions by cross referencing the province involved with matrixed geologic and slope criteria.

(4) **Determine** from the matrix table the degree of erosional-impact predictable, and make land-use decisions accordingly.

A descriptive assessment method was selected to qualitatively evaluate the potential for algal growth problems and to determine the amounts of trace-metal accumulation in river bottom sediment.

Despite high nitrogen and phosphorus concentrations in the Willamette, excessive growths of algae have not been observed. The reason might be any one of several, including trace-metal limitations, unfavorable water temperatures, high summertime turbidities, or short water detention times. Conversely, the river environment could possibly be approaching a condition in which large, problem-causing growths might begin to occur.

As applied in the algal study, descriptive assessment embodied problem definition, devising of hypotheses, collection

would then be subjected to laboratory analyses to determine amounts present in specific reaches. The most interesting results were obtained for zinc, lead and copper. Zinc, for example, was present in normal background conditions throughout most of the river, but in polluted conditions below the outfalls of three ground-wood pulp mills in the Newberg Pool and Tidal Reach sections. In contrast, the enriched lead concentrations occurred in discrete locations—urban areas—rather than in a large downriver zone. This suggested

Aerial view of Willamette River as it passes through Portland, Oregon. Photo taken from altitude of 15,000 ft. by Corps of Engineers in October 1977.

to the study group that the lead pollution resulted largely from storm drainage off streets and roads. High copper concentrations coincided with high zinc and lead occurrences, but copper sources were less readily identifiable. Possible sources included secondary municipal effluents in addition to urban drainage and the pulp and paper mill effluents.

Trace-metal concentrations determined in the study indicated a clean environment with the exception of a moderate enrichment of zinc, slight enrichment of copper and lead, and pollution by several metals in an industrial slough near Albany. The zinc enrichment resulted primarily from use of zinc hydrosulfite in the three mills; a usage which ceased as a result of state direction in July 1977. The study results suggest that no metals were present in the Willamette River at concentrations which might represent an immediate ecological threat. However, from a resource management standpoint, further studies are needed to assess how zinc concentrations in the Tidal Reach respond to the aforementioned ban; the amount of lead entering the river in urban drainage and combined sewer overflows; and, the ultimate fate of metals discharged into the aforementioned industrial slough.

Answers to these questions still will not define the relationship of trace-metal concentrations in Willamette sediments to possible long-range potentials for toxic effects. Still needed is a quantum leap in the understanding of aquatic ecosystems so that further studies can assess this critical relationship.

The Willamette Study emphasized the development of approaches, methods, and data programs that would be useful in the assessment of other river basins. From this effort, and from the other study results, certain findings emerged of relevance to the scientific and engineering community:

- ☐ There is need for synoptic data collection programs to augment or replace routine monitoring- and surveillance-type programs.
- ☐ Mathematical models must be formulated from realistic data and reliable assumptions—At present there are severe limitations to applied mathematical modeling of trace-metal distribution and algal growth problems.
- ☐ The secondary treatment of point-source discharges drastically changes the self-purification characteristics of rivers.

General implications of the Willamette River Basin Study included the need for localized studies, since rigid nationwide standards and regulations—applied to complexities such as river basins—are likely to result in unneeded expenditures in some basins and undesirable quality in others. Additionally, while wastewater treatment always will play an important role, it is not the sole means of river-quality management. Other defensive and offensive strategies, i.e. low-flow augmentation and land-use planning, are also needed. Cost considerations are also paramount. Reliable data to support sound resource planning and management does cost money. However, the General Accounting Office has estimated that the Willamette Study potentially could save tens of millions of Federal, State, and local dollars. Similar savings could possibly be realized in many river basins through properly conducted river quality assessments. ■

Events, Deeds & Deliberations

New Dealers Reunite at Fort Peck

by **Carl V. Patton**
Barry N. Checkoway

In August 1977, a week-long 40-year reunion was held in Fort Peck, Montana to commemorate the construction of the world's largest earthen dam, a huge PWA project of the 1930's. What caused more than two thousand people in their 60's and 70's to return to this remote part of Montana?

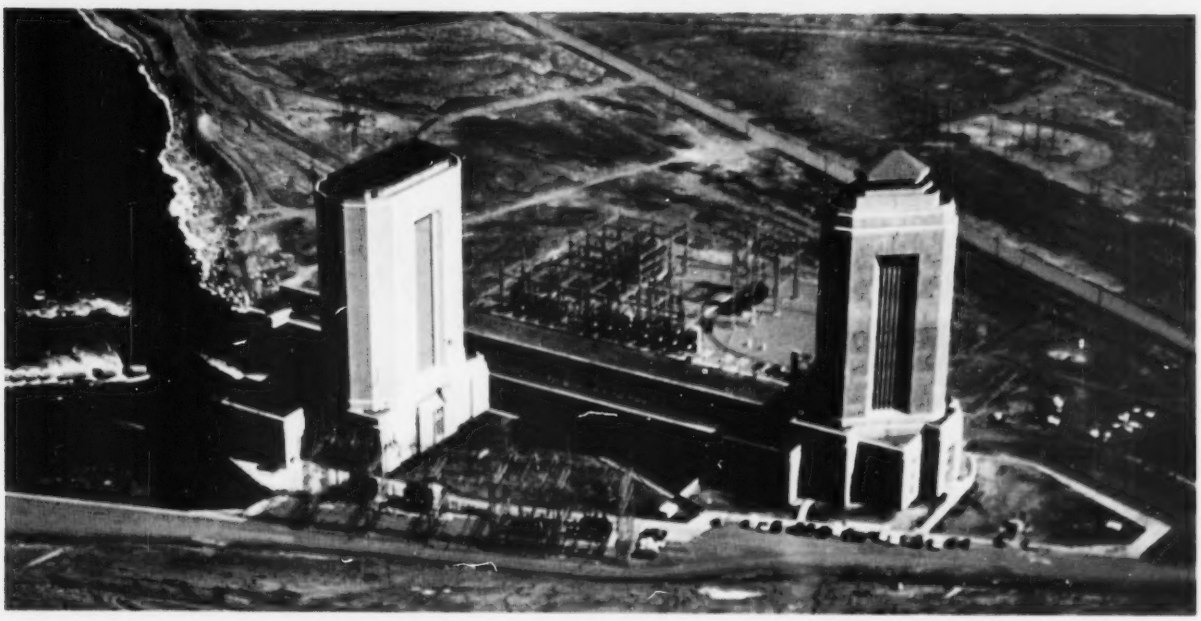
Early in the week the ex-dam workers began to return, pulling their campers into Big Muddy Sportsman's Park Trailer Court. They came from all parts of the country—from California, Oregon, the Dakotas, Wisconsin, even New York. Reunion organizers, aided by the Corps of Engineers, had spent more than a year in tracking down the workers and planning the reunion.

The Fort Peck Project was one of the great work-relief efforts of the New Deal. The image is that in the depths of the Depression, construction of a mighty dam would help get the national economy rolling again. Here was a public works project which promised to improve navigation and promote commerce on the Missouri River; to provide water for irrigation and to allow farmers to ship grain more cheaply to distant markets; to stabilize a major river and control its floods; and to generate hydroelectric power for industry, homes, and cities across the nation. Best of all it would provide work for Montana's unemployed. The aim was to get as many people working on as many projects in as many places as possible. The construction of Fort Peck created tens of thousands of jobs at a time when jobs were unavailable elsewhere.

To house the workers, Army engineers planned and built an entire new town. It was fully equipped with a range of housing types, an elementary school, chapel, hotel, community center, hospital, barber shop, post office, grocery store, and cafe, all overlooking the river and dam. The town was designed according to "good planning principles" and remains a model of physical planning of its time. It demonstrated the power of the national government to reach into the high plains, take raw land, clear it, and assemble an entirely planned settlement.

At the dam site, any time, day or night, one could find a technological revolution in the making. Construction of the dam was considered an engineering feat of huge proportions. Thousands of individuals struggled to harness a mighty river. Men were locked in dramatic combat with nature, digging and scraping to put millions of cubic yards of silt and dirt into the dam, dredging water and dirt from the river bottom and pumping it into a mountain of mud, building highways, extending the railroad, constructing a power line, pouring concrete.

The completed dam was considered a milestone in engineering history. It was the largest earthen dam in the world, fully five times larger than any ever built. Its main embankment was four miles long and held more than 126 million cubic yards of earth. The lake it created was 134 miles long, with 1520 miles of shoreline and a capacity of impounding 19 million acre-feet of water. It was served by the largest single power transmission line ever built, employed over 50,000 different persons at the site, and cost over $170 million. It tamed a mighty river and



"Maybe I'll surprise you," says deckhand Phil Little, one of the few with a differing opinion, "but I think they ought to pass it. The government's got a lot of money in this river. If the truckers have to pay, why don't we?"

In the pilot house, John McNeil demurs.

"It's like you go over here to some little stream," he says, "and catch you a mess of fish. Then that fellow come up and says, you got to pay me for those catfish. It's not right.

"It ain't the idea of paying the $3. It's the idea of paying for a river. It's not right." ■

First Chapters in New Water Data Handbook Published

The Introduction and Chapter 5 of the new, expanded edition of the internationally popular "National Handbook of Recommended Methods for Water-Date Acquisition" are now available, according to the U.S. Geological Survey, Department of the Interior.

Nearly 10,000 copies of the preliminary edition published in 1972 have been distributed, and the new edition is expected to be even more widely used as the basic handbook for standardized methods of collecting water information. Copies of the Introduction and Chapter 5 are available from the Office of Water Data Coordination, U.S. Geological Survey, 417 National Center, Reston, Virginia 22092. ■

Land Use: Tough Choices in Today's World

Over the last decade the debate over land use issues has taken many forms at all levels of government. Programs have been adopted and tried at the state, county, and municipal levels, and the federal government, while not enacting proposals, has initiated programs that regulate the use of land.

The Soil Conservation Society of America recently published the proceedings of the 1977 national symposium, "Land Use: Tough Choices in Today's World," a comprehensive review of land use planning problems, implementation experiences, and the courts' reaction to those programs. The 53 papers in the book were presented at the Society's symposium, which attracted 500 professionals and laymen to discuss the progress of land use planning.

Presented by planners; natural resource specialists; attorneys; federal, state, and local government officials; landowners; and laymen, the papers deal with facing the tough land use choices; the competition for land; preserving land for food and fiber; providing land for living space; setting aside land for natural space; federal and state involvement in land use planning; and a special section on the role of citizens, landowners, planners, elected officials, developers, attorneys, and the courts in the land use planning process. ■

Coming Events

The International Conference on Water Pollution Control in Developing Countries, Bangkok, Thailand, February 21-26, 1978.

5th Energy Technology Conference and Exposition at Washington, D.C., February 27-March 1, 1978.

Symposium on Technical, Environmental, Socio-Economic and Regulatory Aspects of Coastal Zone Planning and Management at San Francisco, Calif., March 14-16, 1978.

National Wildlife Federation Annual Meeting at Phoenix, Ariz., March 16-18, 1978.

North American Wildlife and Natural Resources Conference at Phoenix, Ariz., March 18-22, 1978.

Joint Annual Conference of Interpretive Naturalists and the Western Interpreters Association at Tucson, Ariz., April 5-9, 1978.

21st Annual Conference of the International Association for Great Lakes at University of Windsor, Ontario, Canada, May 9-11, 1978.

23rd Summer Institute in Water Pollution Control at Manhattan College, Bronx, N.Y., May 22-26, 1978. ■

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